



COMMITTEE OF THE PRIVY COUNCIL FOR
AGRICULTURAL RESEARCH

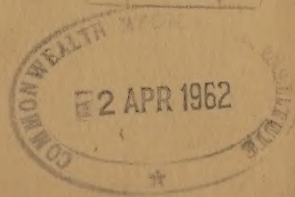
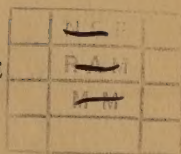
REPORT OF THE
AGRICULTURAL RESEARCH COUNCIL
FOR THE YEAR 1960-61

*Presented to Parliament by the Minister for Science
by Command of Her Majesty
March 1962*

LONDON
HER MAJESTY'S STATIONERY OFFICE

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AGRICULTURAL RESEARCH COUNCIL

at Date of Report

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THE REPORT OF THE COMMITTEE OF PRIVY COUNCIL FOR AGRICULTURAL RESEARCH FOR THE YEAR 1960-61

TO THE QUEEN'S MOST EXCELLENT MAJESTY,
MAY IT PLEASE YOUR MAJESTY,

The Lords of the Committee for Agricultural Research of Your Majesty's Privy Council humbly submit to Your Majesty a Report of their proceedings during the year from 1st April, 1960, to 31st March, 1961.

2. During the financial year 1960-61, Parliament provided a total of £5,605,000 as a grant-in-aid of the Agricultural Research Fund, the original grant-in-aid of £5,270,000 having been increased by a supplementary estimate to provide for the cost of pay awards to scientific and experimental staff. The total was based on estimated current expenditure of £5,344,500 gross, receipts of £325,100 and capital expenditure of £585,600 on buildings and special equipment.

3. During the year under report we appointed two new members to the Agricultural Research Council: Emeritus Professor Alexander Robertson, M.A., B.Sc., Ph.D., LL.D., F.R.S., formerly Heath Harrison Professor of Organic Chemistry, University of Liverpool, who filled the vacancy arising from the appointment of Dr. E. G. Cox, F.R.S., as Secretary of the Council, and Alastair Campbell Frazer, B.S., M.D., D.Sc., Ph.D., F.R.C.P., Professor of Medical Biochemistry and Pharmacology in the University of Birmingham, on the retirement, after ten years' service on the Council, of Professor K. Mather, C.B.E., D.Sc., Ph.D., F.R.S. We also appointed, for a second term of five years, Sir Hans Adolph Krebs, M.A., M.D., D.Sc., F.R.C.P., F.R.S., Whitley Professor of Biochemistry in the University of Oxford.

4. Your Majesty has been graciously pleased to confer the honour of Knight Bachelor on John Neish Ritchie, C.B., B.Sc., D.V.Sc., F.R.C.V.S., D.V.S.M., F.R.S.E., a member of the Agricultural Research Council.

5. During the year, the Royal Society of Edinburgh elected to its Fellowship David Lowe, C.B.E., Deputy Chairman of the Agricultural Research Council.

6. We have received from the Agricultural Research Council a report, which is submitted herewith, upon the progress of its work during the year ended 31st March, 1961. This differs in some respects from the pattern followed in recent years, in particular by the omission of accounts of the research in progress at the research institutes and units. The Council will publish shortly a revised edition of its booklet "The Agricultural Research Service" which will include descriptions of the nature of the work of each institute and unit. A summary of the expenditure from

public funds in these institutes and units is, however, given in an appendix to the report.

7. An account is given of two diseases of animals, scrapie in sheep and leucosis in poultry, on which research has been of unusual difficulty. Both have required special action on the part of the Council.

8. An agreement has been made between the Pirbright Research Institute and the Wellcome Foundation for the commercial production for sale abroad of a range of attenuated live vaccines for the control of foot-and-mouth disease.

9. The Council has had under consideration the difficulties of growing crops, especially tomatoes, under glass in this country in competition with Mediterranean countries which enjoy a more favourable natural climate, particularly a higher light intensity. The possibility of turning to alternatives, for example pot plants and cut flowers, needs to be explored. The difficulty with these crops is that demand for them is greatest in winter when light intensity is lowest. The Council has agreed to set up a Unit of Flower Crop Physiology under Professor O. V. S. Heath, F.R.S., at Reading University to study especially the effects of light intensity and its interactions with day-length and cold treatments on growth and flowering. The practical end in view is to circumvent the disadvantages imposed by the low light intensity of the British winter.

10. The report describes the Council's system of Visiting Groups which constitutes one of the principal means by which it exercises general oversight and control of the research programmes of the institutes. Brief accounts of the research in progress at those stations which received Visiting Groups during the year under report are included.

On behalf of the Lords of the Committee for Agricultural Research of Your Majesty's Privy Council.

HAILSHAM,
Minister for Science.

E. G. COX,

*Secretary to the Committee of Privy Council
for Agricultural Research.*

15th March, 1962.

THE REPORT OF THE AGRICULTURAL RESEARCH COUNCIL FOR THE YEAR 1960-61

To the Lords of the Committee of Privy Council for Agricultural Research

May it please your Lordships,

The Agricultural Research Council begs leave to submit the following Report upon its proceedings during the period from 1st April, 1960, to 31st March, 1961.

FORM OF THE REPORT

The form of this, the fifth Annual Report of the Agricultural Research Council to Parliament, differs in some respects from the pattern followed in recent years. In particular, the reports of the research in progress at the institutes and units financed by the Council have been discontinued. Most of the institutes publish periodical reports which give accounts of their work in much greater detail than is possible in the brief reports hitherto prepared by the Directors for inclusion with the Council's Annual Report. For those who require only a general outline of the work of the institutes and units it is proposed to publish shortly a revised edition of the Council's booklet "The Agricultural Research Service". This will describe the organisation of agricultural research in this country and contain full descriptions of the nature of the work of each institute and unit; it will be brought up to date more frequently than in the past.

Although this Report omits summaries of the work of the institutes, subsequent paragraphs describe the system of Visiting Groups adopted by the Council to review their research programmes and it has been considered appropriate to include brief reports of the research in progress at those institutes which received Visiting Groups during the year.

During the last three years the Reports have included articles by experts, each covering a selected topic within the sphere of agricultural research. Twenty-five articles have been included in this series and it is considered that, as a representative cross-section of agricultural research has now been presented, these can, for a year or two at least, be discontinued.

A new feature of the Report is the addition at Appendix II of a summary of the Council's expenditure showing in particular the cost—both for maintenance and capital—of each of the research institutes and units.

FOOD RESEARCH

In the past, scientific members of the Council have been appointed "on account of their qualifications in one or other of the basic sciences underlying agriculture". The Committee of the Privy Council, as recorded elsewhere, has appointed Professor A. C. Frazer to be a member of

Council, and this is the first occasion on which an appointment has been made on account of the member's interest in subjects underlying nutrition and food science. During the year the Council has also made its first grant in aid of research on a problem relating to food; this was for research on the distribution and diffusion of solutes in processed foods at the Royal Technical College, Glasgow.

In March, 1961, the Research Establishment and Experimental Factory at Aberdeen, which had been operated under the control of the Ministry of Agriculture, Fisheries and Food for the study of methods of producing dehydrated foodstuffs and the development of an accelerated freeze dryer for food, was closed down, since the process had been brought to a point at which it could be commercially exploited. Following discussions with the Ministry, the Council agreed to assume responsibility for continuing some of the general research on food problems which had been undertaken at the Establishment. A number of members of the research staff were accordingly transferred from Aberdeen to the Low Temperature Research Station at Cambridge and the Council took over responsibility for continuing two studies (the biochemistry of dehydrated muscle fibre and the significance of carotenoid breakdown in fruit and vegetables) which were being supported by grants from the United States Department of Agriculture under Public Law 480.

The Council's plans for the establishment of a small laboratory at Cherry Hinton for the development of meat research concerned particularly with carcass quality have also been carried forward, after some delay, and the laboratory was brought into operation shortly after the end of the year under review. This will provide much needed facilities, not previously available to the Council, for handling whole carcasses of large animals and freshly slaughtered material.

The Council has recently received authority to establish a meat research organisation. The Government has announced that the meat industry will be called upon to make a contribution towards the capital and recurrent costs of this research.

LEUCOSIS RESEARCH

Poultry keepers have always been troubled by the occurrence of disease in their flocks but the rapid spread of intensive methods of housing the birds and the small margins of profit now obtained, especially in the broiler industry, have heightened considerably their awareness of the importance of disease. One of the most important of the poultry diseases is the so-called avian leucosis complex; it has been estimated that approximately one-third of the mortality of birds in Britain during the laying period is due to this condition, and the annual loss it occasions must exceed four million pounds.

Avian leucosis is not a single disease but a collection of diseases referred to as the leucosis complex, the most common feature of which is the presence of increased numbers of "white cells", similar to the leucocytes of the blood, in different parts of the bird's body. No doubt the confusion of symptoms that results from this complexity and the widespread occurrence of "leucosis" are responsible for the seventy or so English

synonyms for the disease that exist, the best known of which is fowl paralysis. The number of diseases within this complex, their relationship to one another and the various causes of them are at present uncertain. The disentangling of the strands composing this knot is obviously one of the first jobs to be tackled; much work has already been done and many classifications of the leucosis complex have already been suggested, though in the absence of exact knowledge none can yet command universal acceptance. The following rough grouping illustrates the problem.

One form of leucosis is characterised by paralysis of the bird—paralysis of the legs, wings, and even of the digestive and respiratory systems—brought about by changes that occur in the nerves serving these structures. This form, known as neural lymphomatosis, fowl paralysis or Mareks disease, is very frequently encountered in this country, and it is the one chosen for intensive investigation by the workers at Houghton Poultry Research Station. There is some evidence that the changes that occur in the nerves may be the result of a process of chronic inflammation. Standing in marked contrast to neural lymphomatosis, especially if this explanation is correct, are the true leucoses of poultry, in which the blood is flooded with immature blood cells, usually immature red cells (erythroid leucosis) but occasionally white cells (myeloid leucosis). These diseases are less common than neural lymphomatosis and are characterised in the bird by listlessness, wasting, and the greyish watery quality of the blood. The leucoses of poultry are analogous to the leucaemias of man (and of other species) in that they result from the uncontrolled proliferation of blood-forming cells and are thus of interest to cancer research workers. Between these two types lies lymphoid leucosis, also called visceral lymphomatosis, or big liver disease, in which the internal organs of the bird—the liver, kidney, heart, spleen and ovary—have severally or individually become enlarged and changed by the presence in them of masses of white cells. These, together with fowl paralysis, are the forms which occur most frequently.

Other forms which have previously been considered as part of the complex also exist but are of much less importance. One form, known as "grey eye" or ocular lymphomatosis, is a condition in which the iris of the eye is infiltrated with white cells, changing the colour of the iris to a pale grey and distorting its shape so that blindness may result. The second form is a condition known as "marble bone" or osteopetrosis in which the bird's limb bones are grossly thickened and mis-shapen.

The difficulty of disentangling these entities is enhanced by the fact that they may occur together in the same flock or even the same bird. This is unfortunately true of the two forms of major importance, fowl paralysis and lymphoid leucosis (visceral lymphomatosis), and has undoubtedly complicated the interpretation of the results of experiments. It is very difficult to answer important questions such as "Is leucosis transmitted through the egg?" when the "leucosis" being investigated may be two or more different things occurring simultaneously during any experiment or survey.

A serious obstacle to the extension of research in this country is the widespread existence of leucosis in the poultry population, since experiments would always be of questionable value unless it were certain that

the birds under experiment had initially been free from all forms of leucosis yet were known to be susceptible to them. The first essential was therefore a supply of birds free from but susceptible to leucosis. Accordingly the Council decided some time ago to produce such birds by setting up a Unit in which a number of families of poultry from stock believed to be free from leucosis would be reared in isolation from other poultry and from each other. Any strains in which leucosis appeared under these conditions, or which on test displayed undue resistance to the condition, would be discarded. One or more of the lines possessing the criteria of susceptibility to the complex but freedom from it would then be maintained in isolation for the future supply of birds for experimental purposes.

For the site of this "Production Unit" the old Poultry Genetics Station at Boxworth, eight miles from Houghton, is to be used. The establishment of the Unit has been delayed because it has been necessary to ensure that no poultry are kept close at hand from which disease might spread to the isolated stocks. The modification of the existing buildings and the erection of additional ones is now in progress.

It is hoped that University Departments and other institutions will be prepared to undertake fundamental studies on leucosis when a supply of leucosis-free susceptible birds become available. The complete plan for leucosis research includes the establishment of an Experimental Unit quite separate from the Production Unit, in which experiments requiring conditions of stringent isolation can be undertaken with the leucosis-free, susceptible stock from the Production Unit. The Experimental Unit is adjacent to the Houghton Poultry Research Station. Both Units will be under the control of the Station for the purpose of administration and scientific supervision. There will, however, be strict isolation between the buildings and staff of the Leucosis Units and those of the main Station.

SCRAPIE

Scrapie is an unusual and somewhat mysterious disease of sheep the extent of which in this country has not been determined with certainty. It has been recognised in Europe for more than two centuries but it does not seem to be endemic elsewhere—in Australia, the United States and Canada for example. As occasional outbreaks in those countries have been attributed to sheep imported from this country, such importations have now been stopped. This restriction on our export of sheep, the challenge presented by the unusual features of scrapie, and the need of human and veterinary medicine for more information on peculiar diseases of the nervous system, have all led to an intensification of research into scrapie.

A sheep affected with scrapie bites and rubs itself as though it has an itch and walks unsteadily. These manifestations of something amiss, slight at first, become progressively worse until the animal dies, usually some months later, though some survive more than a year. Recovery is rare. When the internal organs are examined little can be seen to account for the abnormal behaviour or to indicate how the disease has progressed. Minute examination of the nervous system has revealed that some of the

specialised nerve cells (neurones) contain globules of fluid (vacuoles) which are much more numerous in the neurones of sheep suffering from scrapie. This finding stimulated a more careful search and other signs were found that neurones were degenerating and dying and were being replaced by unspecialised cells (astrocytes). Although the cause of these changes is not known, it is possible that their nature and position may help to explain the symptoms of the disease. Further work, some of which is in progress, is needed to link changes in structure and function of nerves and nerve cells with the signs of the disease and its progress.

The blood serum of an animal with an infectious disease is frequently altered in composition, and contains protective antibodies that will combine very specifically with the invading organism or its products, both within the body and outside. The presence of specific antibody in serum can be used to establish an accurate diagnosis of many diseases. No changes have been observed, however, in the serum of animals with scrapie, and there is at present no means of diagnosing scrapie other than by clinical observation.

The cause of scrapie remained quite unknown until an unfortunate accident provided a lead. Louping-ill vaccine is prepared from sheep brain, and when three apparently similar batches of vaccine prepared in 1935 were used to immunise sheep, cases of scrapie occurred during the next two years in sheep inoculated with one particular batch. Each batch had been treated with a concentration of formalin sufficient to inactivate a louping-ill virus. The circumstances of this accident seemed to indicate that one of the vaccines had been prepared from sheep affected with sub-clinical scrapie which had thereby induced the condition on inoculation into sheep in the field. It was subsequently confirmed that scrapie could be passed from sheep to sheep through the medium of a suspension of infected brain tissue and the condition has now been transmitted through several generations of sheep.

The agent that provokes scrapie experimentally has unusual features. It will pass through filters that hold back bacteria and larger organisms and would therefore normally be considered to be a virus. However, it has survived heating in boiling water for periods which kill practically all known viruses and it is resistant to the concentrations of certain chemicals which normally inactivate viruses. Various speculations on the pathogenesis of the disease have been framed to explain this unusual behaviour; one of these was that the agent producing scrapie experimentally is not a virus but a substance which when injected into brain simply triggers into action a latent virus already there. This view is not now widely held.

Not every sheep inoculated experimentally with material capable of producing scrapie takes the disease. Injection of material directly into the brain gives the best results, but even with this method seldom more than half the animals inoculated develop the disease. Different breeds of sheep seem to vary in their susceptibility to the transmission of scrapie; even with individual breeds there may be differences suggesting lines of varying sensitivity. The idea has developed from this, and it has some

support from analyses of case histories, that constitution, genetically determined, may play a very important, perhaps an essential role in determining whether an animal can develop scrapie. Experiments are now in progress to define the importance of heredity.

Ignorance of how the disease spreads naturally, its long incubation period, the relatively high cost of the natural host, and the probability that in any experiment no more than half the animals inoculated with active material will develop scrapie, have all made the investigation of the disease difficult and have prompted a search for less tedious and expensive methods. The use of cultures of living tissues as a medium on which to grow viruses has been exceedingly useful in many investigations; unfortunately it has not been possible so far to grow the infective agent of scrapie on cultures of sheep (or other) tissues, but efforts to do so are still being made. The search for other species of animals in which scrapie may be induced was unrewarded until recently when it was discovered that goats are very susceptible to experimentally-induced scrapie; all goats so far inoculated have taken the disease. The use of the goat does not materially reduce the cost of experiments but trials in this species are more easily interpreted. Some preliminary work in mice looks promising and if it can be confirmed that this species is susceptible many experiments which so far have been deferred on account of the cost of sheep and goats could be undertaken.

There are many diseases of the nervous system in man, some of them apparently involving degeneration of nervous tissue, about which more knowledge is needed. The study of similar diseases in different animals is frequently rewarding, and it is possible that the study of scrapie in sheep might contribute towards a better understanding of nervous disease in general. There is one particular human disease, Kuru, which shows surprising similarities with scrapie. Kuru affects the natives of part of Australian New Guinea; the disease is insidious, is characterised by progressive locomotor ataxia and tremors and is followed by death in six to nine months. Vacuolation and degeneration of neurones occurs and they are later replaced by astrocytes. No significant changes in the blood have been detected and the causal agent is unknown. Genealogical data seem to show that a genetic defect giving susceptibility to the disease and related perhaps to a single gene is the most likely explanation of the condition; there is, however, a difference of opinion on this.

Modern research on scrapie started at the Animal Diseases Research Association's institute at Moredun and has continued to grow there. The present Director of the Council's Field Station at Compton was one of the original investigators at Moredun, and research into scrapie has developed under his guidance at Compton. These two stations do most of the research on scrapie, but contributions are made also at Oxford and Cambridge Universities, the former supported by the Nuffield Foundation. The Council was recently able to obtain the advice of a distinguished American virologist, Dr. H. Koprowski, on its work in this difficult field. Dr. Koprowski was in this country for three weeks and saw virtually all the research on scrapie before giving his impressions to the Council's special group on scrapie.

Little, if any, research on scrapie is done in the United States. The United States Department of Agriculture, however, using funds available under Public Law 480, has agreed to give generous support to the work at Compton and Moredun; a grant of £106,940 has been promised to these institutes during the next five years.

COMMERCIAL PRODUCTION OF FOOT-AND-MOUTH VACCINES

Foot-and-mouth disease is prevalent, to a greater or less degree, in many parts of the world and the virus is known to exist in a number of different types.

While there is no doubt that for countries in which the incidence of the disease is low, as in Great Britain, eradication by slaughter is the best policy, there are many countries where the disease is wide-spread and such a policy is not practicable. Progress in control in such countries depends on the application of effective vaccine. Vaccination against the disease becomes more complicated as the number of types prevalent in an area increases, since immunity to one type does not extend to other types. Much has been done in Europe with vaccines prepared from killed virus, but there are several disadvantages in their application in countries with a less developed agricultural industry.

While the Foot-and-Mouth Disease Research Institute at Pirbright has contributed to the knowledge of such vaccines, much of its effort in this field has lately been directed to the development of live virus vaccines in which the virus is modified to a point where its immunising value is retained but it is no longer capable of producing the disease. This kind of vaccine is generally easier to produce, effective in smaller doses and gives longer immunity. As a result of several years' work, the Institute has succeeded in producing modified strain vaccines of this class for use against a number of different virus types, notably those found in Africa, and extensive field trials have been carried out.

The results of the trials were most encouraging and showed that the new vaccines could make a most valuable contribution to the control of the disease throughout the world. However it became apparent that the Institute would require assistance with the further development of the vaccines for commercial production if the present staff were not to be diverted from their proper function of research. In 1960, therefore, the Governing Body of the Institute proposed that they should enter into an agreement with a suitable pharmaceutical firm for the development and production of a range of such vaccines based on the results of the Institute's research. As a result, an agreement was reached between the Institute and the Wellcome Foundation for the production of vaccines for sale abroad. Because of the strict disease security precautions necessary against the escape of the virus, it has been decided that production should take place on the premises of the Research Institute. Under the terms of the agreement, the Institute will be responsible for providing the building (for which they will receive a grant from public funds) and the Foundation will provide equipment and staff. The production and sale of the vaccines will be undertaken by the Foundation and the gross profit from these sales will be divided equally between the parties to the agreement.

Although plans for the building are only in process of being drawn up, collaboration between the two parties on the preparation of vaccine for extensive field trials has already begun.

FLOWER CROP PHYSIOLOGY

In spite of all advances in knowledge and skill, the profitability of a commercial crop still depends very much on the climate of the region where it is grown. It is true that, when the natural climate does not provide the conditions that the plant needs, knowledge and skill may be applied to the creation of an artificially modified climate round the crop; but the cost of doing so increases with the amount of modification that is necessary and affects the economics of production. Unless there is a politically protected market, profit becomes unlikely as soon as the cost of modifying the local climate exceeds that of transporting the product from some other region where the natural conditions are nearer the ideal.

These simple principles are only too familiar to the growers of crops under glass in Britain. They, of all crop producers, spend most per acre in modifying the climate and are consequently most vulnerable to competition from countries favoured with a natural climate much nearer what their crops require. These are especially the Mediterranean countries, which enjoy not only higher mean temperatures but also more sunshine than we get even in our sunniest districts, where the glasshouse industry tends to congregate.

The importance of sunshine must be stressed in any discussion of the basic problems of the industry, because there is no doubt that low light intensity, especially in winter, is the feature of our climate that has to be taken most carefully into account in the planning of research on glasshouse crops. The glasshouse is essentially a device for providing, when required, temperatures higher than those outside. It does that effectively, though expensively and at the disadvantage of creating cooling problems on some summer days. It does not provide a higher light intensity—on the contrary, however well designed, it reduces the amount of light falling on the plants within. Light intensity may therefore limit crop production even in summer when on a dull day the intensity in an unshaded glasshouse at midday may be only a twentieth of that measured outside on a clear day. On winter days the light intensity under glass is often barely sufficient for any photosynthesis to take place.

The deficiency cannot be made good, and must therefore be accepted. Artificial light can be used on small seedlings, or to lengthen the day for control of flowering which needs only a low intensity; but to provide for growing plants the intensity of artificial light necessary for photosynthesis and productive growth is not feasible on a commercial scale.

This consideration governs the choice of alternative crops for the large section of the glasshouse industry that is mainly dependent on the tomato and faces the most serious threat from developments in the Mediterranean countries. While trying in other ways to improve their competitive ability, tomato growers are naturally, as a measure of insurance, seeking alternative crops which should evidently be those that are difficult and expensive to transport from overseas. The most promising

appear to be pot plants and cut flowers—for which the demand is greatest in winter when the light intensity is lowest. Evidently considerable ingenuity will be called for to circumvent the disadvantages of our climate and produce flowers out of season at prices that will stimulate demand.

One possible approach to the problem is suggested by the behaviour of the bulb flowers which do their photosynthesis in summer, accumulate reserves, and after a period of dormancy flower in winter or spring. Their abilities are already turned to account, for example, in the forcing of tulips which can be brought into flower in winter by providing warmth and low-intensity light. The underlying principle may be capable of extension to species other than those that store reserves in bulbs or corms. "Short-day" plants in general (i.e. those that flower naturally only when the days are short) must build up their reserves in the long days of summer. Any species that does that, and is amenable to inexpensive methods of retarding or forwarding flowering, may be a potential winter flower crop. On the other hand "long-day" plants could perhaps be grown under artificially shortened days outdoors in summer to build up reserves, and induced to flower under glass in winter by long "days" of low-intensity artificial light. All these and other possibilities need to be explored. At the moment we know too little about the physiology of possible flower crops to select the likely "winners". Each species has its own peculiarities, and only experiment can show what each can be induced to do by suitable control of temperature and day length. The first step is to find out how the various external factors control the growth and development of the plants concerned.

The quickest and surest way to get the basic knowledge required is to grow plants in an artificial environment where light, temperature and humidity are all precisely controlled and can be varied independently at will. Until fairly recently this could not be done because of the difficulty in providing artificial light of sufficient intensity. Growth experiments therefore had to be done in glasshouses, which control the minimum temperature but little else. The fluctuating natural daylight could only be modified by shading, though "day length" could be shortened by screening or extended by low-intensity artificial light. Much useful research has been done under such conditions, but only at the expense of tedious repetition and without certainty in all the results.

In the last few years, thanks largely to the development of fluorescent lighting and other advances in lamp technology, it has become practicable to construct cabinets or small rooms in which plants can be grown to maturity in artificial light alone, with the other environmental factors also under precise control. Plant physiologists have quickly appreciated the value of this new research tool. Controlled-environment equipment has been installed on a small scale in many laboratories but its wider application has been waiting for improvements in design—especially in the direction of ensuring even illumination of the experimental plants—and for reductions in cost. The cost is important because a relatively large number of cabinets must be used to study the complex interactions between each environmental factor and the others. Much of the necessary research into design has now been done, and development is in progress.

There are good hopes that costs will be reduced by commercial production of a cabinet of standard design in the near future.

Taking into account both the need for more research into the physiology of ornamental species and the availability of appropriate equipment for the work, the Council has agreed to set up a Unit of Flower Crop Physiology in the Department of Horticulture at Reading University under the direction of Professor O. V. S. Heath, F.R.S., who is already adding much to useful knowledge of the subject and is a leading authority on it. The Unit will be equipped with controlled-environment cabinets as soon as they are available, enabling Professor Heath to extend his present programme to a range of possible new glasshouse flower crops as well as to existing ones on which little physiological investigation has been done.

The research is planned to study especially the effects of light intensity and its interactions with day-length and cold treatments in governing growth and flowering. While the practical end in view will be to circumvent the disadvantages imposed on growers by the low light intensity of the British winter, the immediate object will be to elucidate general principles. To link principles with practice, two further stages of research will be necessary. First, the conclusions reached must be applied to glasshouse experiments done under the closest control that is possible under glass; that is to say in glasshouses specially designed for experimental work. Such experiments will show up any differences there may be between the behaviour of the plant under a level of illumination that is held steady and its behaviour when the light intensity varies continuously as daylight does. Though the results obtained in daylight may well be less clear-cut than those from the cabinets, their interpretation should be greatly helped by the knowledge gained at the first stage. The work at this second stage will be appropriate to a research station such as the Glasshouse Crops Research Institute.

Finally, the results from the first two stages of experimentation must be tested under near-commercial conditions, that is in glasshouses of commercial design but with suitable experimental control of observations. This will need to be done in different districts by several Experimental Horticulture Stations. The three stages of research illustrate well the long series of investigations through which the solution of difficult agricultural and horticultural problems has so often to be approached.

PLANT BREEDERS' RIGHTS

In 1960, the Committee on Transactions in Seeds produced a Report on Plant Breeders' Rights, published in July as a Command Paper (Cmnd. 1092), which embodied their conclusions from a study of the subject extending over three years. The Council, and the directors of several agricultural research institutes, had co-operated in the enquiry.

The main object of the Committee's recommendations is to encourage more plant breeding by commercial seed firms, nurserymen, and private individuals. Their conclusion, in brief, is that this can best be done by instituting something like a patent system for plants, which would confer on the breeder, for a limited period, exclusive personal rights in his variety.

According to the Report, more than half of the total expenditure on plant breeding in the United Kingdom is met from public funds. The Agricultural Research Council, as the body responsible for the oversight of State-aided plant breeding in Great Britain, is therefore closely interested in the matter. The Council has noted with gratification that there is no divergence between the Committee's views and its own on the position of the State-aided institutes in relation to the scheme put forward. Both agree that varieties bred at State-aided institutes should be eligible for the grant of rights in the same way as privately-bred varieties.

They also agree, on a point to which the Council attaches special importance, that the possibility of earning financial rewards from new varieties should not be allowed to disturb the balance of the State-aided work. At present the institutes carefully preserve a balance between breeding to meet the immediate needs of agriculture on the one hand and fundamental research into genetics and plant-breeding methods on the other. Each side of the work stimulates the other. The research is the necessary price of new knowledge, and without it practical progress would soon slow down. On the other hand the research would suffer if divorced from exercise, in the same institute, in its application to practical ends.

The Council believes that there is room for more private effort in plant breeding, but that no foreseeable development of it is likely to reduce the need for State-aided effort, which is complementary and not competitive.

VISITING GROUPS

The greater part of the research carried out under the Council's auspices is undertaken at the various agricultural research institutes that are wholly or mainly financed from Government sources. One of the principal ways in which the Council exercises general oversight and control of the research programmes of these institutes and of the scientific quality of their work is by means of its system of Visiting Groups.

A Group is normally appointed every six years to visit each institute. The members are distinguished scientists and agriculturalists, selected for their knowledge of the various fields of work with which the institute is chiefly concerned; the membership of a Group varies, therefore, according to the range of the institute's activities. The Group generally includes at least one member of the Council who acts as chairman. Accompanied by members of the Council's secretariat, the Group spends two or three days at the institute and examines with the Director the programme of research. Members of the Group discuss with each individual worker the investigations on which he is engaged and any difficulties with which he is faced. The Group then discusses with the director of the institute how its programme of research should develop during the coming six years, and considers its needs for additional staff, major equipment, buildings and land. Finally the Group prepares a report which is submitted to the Council, together with the director's comments on any matter in which he dissents from the Group's recommendations or feels that further explanation is required.

The affairs of many institutes are directly administered by their own Governing Bodies, which are responsible for the disbursement of the

annual grant made available by the Council. In these cases the Group's report, after acceptance by the Council, is transmitted to the Governing Body which, with the Director, then considers how the Group's recommendations should be put into effect. For those institutes which are under its direct control, the Council has recently introduced arrangements to maintain closer contact, throughout the six-year period, between the institutes and the members of the Group.

The Visiting Group system works well and is generally welcomed by the directors and their staffs. The visit provides an opportunity for individual research workers at the institutes to discuss their problems with senior scientists with whom they might not otherwise come in contact; and the report provides a working basis for the director in his relations with the Council's secretariat during the next few years and, very often, useful support for the director in the policies he wishes to follow. Under this system the Council obtains the benefit of authoritative and independent advice upon the activities of each institute at least once every six years, and, if special problems arise during the ensuing period or major changes of policy are mooted, members of the Group can be called into consultation or the Group can, if necessary, be re-convened.

The success of this system depends upon the willingness of those qualified to do so to serve on Visiting Groups. The Council is conscious of the many other calls made upon the scientists and farmers who assist it in this way, and is most grateful to them. During the year 1960-61, Visiting Groups were received by the following institutes:—

Macaulay Institute for Soil Research.

Plant Breeding Institute.

Rothamsted Experimental Station.

Pest Infestation Laboratory.

A brief outline of the work of each of these Institutes is given below.

MACAULAY INSTITUTE FOR SOIL RESEARCH

The Macaulay Institute, located at Craigiebuckler, Aberdeen, takes its name from Dr. T. B. Macaulay who bequeathed the legacy on which it was founded in 1930. It is now one of the group of agricultural research institutes financed by the Department of Agriculture and Fisheries for Scotland with the scientific advice and oversight of the Agricultural Research Council. Like other members of the group, the Institute combines the investigation of specifically Scottish problems with a great deal of basic research that contributes to agricultural progress throughout Britain and even overseas.

In accordance with the founder's wishes, the investigations pursued cover diverse branches of soil science, all of which contribute to one ultimate aim—the maintenance and improvement of soil fertility. The peat, moorland and heath soils of Scotland, which were specially mentioned in his bequest, have always received much attention. As other interests have developed, the proportion of the total effort devoted directly to improvement of peat soils has become smaller; but a continuing interest

in peat is reflected in the strong emphasis on studies of soil organic matter which is notable in several departments.

Several departments are concerned with the occurrence of trace elements in soils and their significance in plant and animal nutrition. This interest started with a study of mineral deficiencies in certain Scottish soils, and in its development has fostered the study of spectrochemical techniques for estimating trace elements in soils and biological materials. The Macaulay Institute is known all over the world for its contributions to that subject.

The Institute established quite early in its history a reputation for researches which combined high scientific merit with great practical interest and since the war it has grown considerably. In 1948 the staff in the Scientific and Experimental Officer classes numbered 26; in 1954 it had doubled; and in 1960 the number had reached 70.

The Macaulay Institute has close associations with the University of Aberdeen, which appoints representatives to its Council of Management. It is recognised by the University as a centre at which postgraduate students may work for the Ph.D. degree. Other scientific visitors come from many parts of the world to study techniques or to conduct research. The number that can be accepted is limited by the accommodation available, but the total of students and other long-period visitors has recently averaged about a dozen at any one time.

The Institute's Annual Report records the progress of researches and shows how, from year to year, the programme is adjusted to meet changing needs. It includes abstracts of scientific papers published during the year. In 1959-60, the Institute's staff published 38 papers in various scientific journals.

RECENT DEVELOPMENTS AND OUTLOOK

Between the Visits of 1954 and 1960 there were several changes among senior staff. In 1958 Dr. D. N. McArthur retired from the Directorship. He was succeeded by Dr. A. B. Stewart, who had been Deputy Director of the Institute until 1954 and subsequently Professor of Agriculture in the University of Aberdeen. Other staff changes during the period led to a regrouping of some of the research sections but did not affect the main outlines of the programme.

A notable feature of the six-year period was the beginning of a solution to a serious accommodation problem. The particularly rapid expansion of staff and programme in the first few years after the war was in line with the general strengthening of the agricultural research service that occurred at that time; but, as at several other centres, it caused some embarrassment by overcrowding both the existing accommodation and such increases as could be provided by temporary buildings. The Visiting Group of 1954 advised that a major building programme was urgently necessary. A phased programme was agreed soon afterwards, and building commenced in 1958. The completion of Phase 1 in 1961 has provided new laboratories for Pedology, Soil Survey, Spectrochemistry and Biochemistry. Phase 2, which began in 1960, will provide for the other departments.

Allowance has been made in the building programme for some further increase in staff, which appears to be inevitable if full advantage is to be taken of the Institute's special techniques and expertise. Without starting any new work, some departments need extra pairs of hands to cope with a growing demand (from within the Institute and from other centres) for routine analyses and other work essential in applied investigations. Some have been waiting for several years for room to house new equipment, which will speed up their work but entail extra maintenance. In addition, several highly promising lines of research have been opened by new discoveries during the last few years, but have not been adequately followed up for lack of laboratory space. These must now be developed and turned, if they fulfil their promise, to practical ends. As the work already going on depends on continuity of effort, it cannot be stopped while new lines are explored. On all these counts some further growth is to be expected; but it will be slower than in former years, and will be directed only to the strengthening of under-manned sections in order to improve the balance of the organisation.

THE RESEARCH PROGRAMME

The summaries of departmental programmes that follow have been prepared from the information supplied to the Visiting Group and from its report. They do not show every detail of the researches in progress, but aim to describe the integration of various approaches to the central subject of soil fertility.

Pedology. The Pedology Department, under Dr. R. C. Mackenzie, was formed in 1959 by bringing into closer association five sections of the Institute which have widely different special interests but a common ultimate objective. The activities of these sections range from the use of X-rays in identifying clay minerals to field studies of the growth of grass on deep peat. Their techniques are correspondingly various; but the interest they have in common is in the genesis of soils and the properties and reactions of soil constituents. Much of the diversity arises from the differences between mineral and organic soils, which necessitate different methods of approach. Two of the sections are primarily concerned with the first, and two with the second.

The sections of *Soil Mineralogy* and *Physical Chemistry* work closely together on a systematic mineralogical examination of soils and on investigations of pure minerals, especially those occurring in clays. One uses chiefly X-ray and optical methods, while the other concentrates on differential thermal analysis (a technique which has been greatly developed by Dr. Mackenzie himself) and chemical methods. Their various complementary techniques are also applied to studies of rock-weathering, designed to elucidate the processes of soil formation.

Soils from many parts of the world are studied to throw light on fundamental problems, but the greater part of the work is concentrated on Scottish soils, and especially on those being mapped by the Soil Survey of Scotland. It is not confined entirely to mineral soils, as some of the techniques are being extended to studies of peat.

The *Peat Ecology* section is engaged (in collaboration with the Department of Agriculture and Fisheries for Scotland) in a survey of peat bogs in Scotland which includes studies of their vegetation and other characteristics relevant to problems of utilisation. The section also collaborates closely with the Hill Farming Research Organisation in researches into the effects of drainage on peat and the vegetation it carries; the effects of fertilizers on the vegetation, both natural and introduced by the sowing of pasture species; and on the recolonization of heather after burning, and the long-term effects of burning on the soil profile. Root studies are included, in which radioactive tracers have been used to investigate the rooting of plants growing in deep peat.

A great deal can be learned about the age and history of peat deposits by microscopical examination of pollen grains found in the peat at different depths. The methods of pollen analysis, used by botanists generally to study the history of changes in vegetation since the Ice Age, have been applied at the Institute for many years in conjunction with the peat survey. The information obtained in this way supplements for Scotland that obtained for other parts of the British Isles at other centres. It is valuable to the survey, and may have practical applications in land utilization. A current short-term activity of the section is a comparison of the horticultural value of different peats used in the preparation of composts.

The *Forest Soils* section is also concerned very largely, though less exclusively than Peat Ecology, with organic soils. It works in collaboration with the Forestry Commission on some problems of the nutrition of trees on various soils, but especially on peat, and is engaged on a long-term study of the effects of afforestation on the physical and chemical properties of deep peat. The close association of two sections interested in alternative uses of peat soils is an obvious advantage to both; and both, while benefiting from contacts with the work of other sections, contribute to the broad objectives of the whole department.

A section of *Soil Analysis* serves all sections of the Pedology Department and also the Soil Survey, for which many hundreds of standard analyses are made every year.

Soil Survey. The Department of Soil Survey, under Dr. R. Glentworth, is simultaneously an integral part of the Macaulay Institute and of the Soil Survey of Great Britain, being responsible under the general direction of the Soil Survey Research Board of the Agricultural Research Council for the Soil Survey of Scotland and closely associated with the Soil Survey of England and Wales located at Rothamsted. The Survey, which began in 1930, is mapping the soils of Scotland on a scale of 2.5 inches to the mile and at a rate of 400–500 square miles a year. It provides a large part of the background to the work of the Institute, as several other departments concentrate much of their attention on soils that have been mapped or are currently being surveyed.

The Soil Survey department also co-operates in the studies of physical and chemical properties of soils by the Department of Pedology, and helps to select contrasting soil profiles for trace element investigations by Spectrochemistry and sites for field experiments by Soil Fertility. Most of the

staff are soil surveyors, operating in six teams distributed over different districts of Scotland. The department also includes a botanist, whose function is to survey and describe the natural and semi-natural vegetation communities and their relation with the major soil groups, thus linking the soil survey with land usage and agricultural practice.

The Soil Survey of Scotland, like its counterpart south of the Border, often receives requests for help with problems that are not strictly agricultural. It is at present helping the South of Scotland Electricity Board to study corrosion in the stub-ends of electric pylons.

Spectrochemistry. The Department of Spectrochemistry, led by Dr. R. L. Mitchell (who is also Deputy Director of the Institute), has an international reputation based on its development of methods of spectrochemical analysis applicable to agricultural problems. Its research has two main aspects. A great deal of attention is still devoted to the improvement of existing techniques and the introduction of new ones, with the objects of achieving greater accuracy and speeding up and simplifying the processes of analysis. Concurrently the techniques already developed are being used in a wide variety of investigations relating to the occurrence and significance of trace elements in soils and biological materials.

Continuing research on techniques is particularly necessary because the department is largely, though not exclusively, interested in elements that occur normally at concentrations of only a few parts per million of the material to be analysed and sometimes at levels that have to be expressed in terms of parts per ten million. The first object is precision in estimating these very small quantities in the presence of large amounts of other things that may interfere with the analysis. At any given level of precision, other considerations become important. Expensive equipment is required, as well as great skill in manipulation. Any refinement of method that leads to greater output of results without sacrificing precision is therefore doubly beneficial by permitting fuller use of the equipment and skill and reducing the cost per analysis.

Most of the department's work using established methods is in collaboration with other departments of the Institute. The distribution and availability of trace elements in soil profiles are studied with the Departments of Pedology and Soil Survey, and the relationship between soil content and plant uptake with the Department of Soil Fertility. These are long-term researches building up a body of useful information about the distribution of trace elements in Scottish soils and their significance in agricultural production. Special attention is paid to soils where trace element disorders of plants and animals occur, such as those carrying herbage with high molybdenum content, or deficient in cobalt, copper or manganese.

To study trace element uptake by trees, a 30-year-old Scots pine has recently been analysed comprehensively, the needles, shoots, bark and wood of each branch being examined separately. Trunk and roots were also sub-sampled. From the complete results it will be possible to calculate the total amount of each trace element in the tree and possibly to estimate the annual uptake and loss.

Spectrochemical methods are applicable to the determination of many organic substances as well as trace elements. The department is collaborating with Biochemistry, Plant Physiology and Microbiology in the application of infra-red spectroscopy to several of their problems.

In addition, the department does a lot of work for other research institutes, as well as serving as a centre for advice on spectrochemical methods. The total number of trace element and other analyses made in a year runs into thousands. In 1960 it was about three times as large as in 1954, but in the same time the assistant staff employed increased by only about a third. These figures indicate the great improvement effected in routine methods by continuous research.

Biochemistry. This department was formed in 1956 under Dr. J. S. D. Bacon. It took up and continued earlier work in the Institute on the chemistry of soil organic matter and has since opened some new lines of research in collaboration with the departments of Plant Physiology and Microbiology.

The investigation of soil organic matter is concentrated for the present on extractable materials, such as humic acids and water-soluble polysaccharides. The study of their nature is designed to throw light on their origin in the soil and on the part they may play in affecting soil structure and plant nutrition. For example, it is still an open question whether certain polysaccharides are derived directly from plant residues or are products of bacterial action. An answer is particularly desired because these substances are widely believed to assist in maintaining the crumb structure of soils.

The collaborative researches in plant nutrition are concerned with the parts played by the soil and by micro-organisms in nourishing the growing plant, influencing its enzyme content and metabolism, and thus affecting its chemical composition at maturity. A noteworthy recent advance is the discovery that certain bacteria isolated by the Department of Microbiology produce 2-ketogluconic acid when grown on simple media containing glucose. This acid chelates calcium and thus brings into solution insoluble calcium salts—a process which may bear on the utilisation of phosphate fertilizers and the weathering of minerals.

Plant Physiology. The Plant Physiology Department is concerned with salt absorption, trace element nutrition, and effects of soil organic matter on plants—all aspects of plant nutrition which link with the interests of other departments and contribute to the general programme of the Institute. Some of the work is collaborative with Spectrochemistry and some with Biochemistry. During the last few years, a great deal of attention has been given to iron deficiency in plants, and the changes in uptake of other nutrient elements which are associated with it. At the same time the effects of iron deficiency on the biochemical mechanism in the leaves have been studied.

The department includes a small section specialising in the use of radioactive isotopes in various physiological experiments. This section serves the whole Institute. It has been collaborating with the Peat Ecology section in tracing the effects of drainage on the root systems of plants growing in deep peat, and with the Department of Soil Fertility in the study of phosphate fixation in soils.

Microbiology. The Department of Microbiology has two main topics of investigation: the first, the role of soil micro-organisms in decomposing soil organic matter; the second, the relations between micro-organisms and the roots of higher plants. As a background to both it makes detailed studies of some of the more important organisms involved.

In the study of decomposition, most attention is being given to the break-down of lignin by fungi, which is followed in detail with the help of the Department of Spectrochemistry in identification of the intermediate products by infra-red spectroscopy.

The investigation of micro-organisms in the root region (rhizosphere) of plants is producing highly interesting results. Bacteria have been isolated which can dissolve solid particles of phosphate in culture medium, and collaborative work with the Department of Biochemistry has revealed the mechanism by which they work. Their action in the soil is now being studied jointly with the Department of Soil Fertility.

This advance has opened up a wider study of the part played by soil micro-organisms in the weathering of rock minerals, in which the Departments of Pedology and Spectrochemistry are also interested. Organisms have already been found which can dissolve silicates, and the outlook for this co-operative effort by four departments is very promising.

Another item of the department's programme that links with those of Biochemistry and Spectrochemistry is an investigation of the effects of deficiencies of trace elements on the growth of certain soil micro-organisms, including those involved in the breakdown of lignin.

Soil Fertility. This department, under Dr. E. G. Williams, has both research and advisory functions and serves as a firm link between the Institute and agricultural practice. The advisory work is restricted to the area served by the North of Scotland College of Agriculture and is done in collaboration with that institution. The research programme is directed towards the improvement of manurial practice by studying the nutrient status of different soils and the fertilizer requirements of various crops. It impinges naturally on the special interests of every department in the Macaulay Institute, and may be described as translating, integrating and applying the research findings of all. The work embraces field experiments (distributed over different soil types at sites chosen in consultation with the Soil Survey), pot experiments (providing more closely controlled conditions) and laboratory studies (including all the necessary analyses).

Dr. Williams has for many years had a special interest in the phosphate nutrition of crops, with particular reference to the availability of inorganic phosphate in the soil and the many factors that affect it. There is consequently some emphasis on this subject in the programme, but not to the prejudice of an all-round investigation of the responses of crops to the major nutrients and trace elements and of methods of applying fertilizers.

Statistics. The Institute has a small Statistics section which provides a service for all departments in the design and analysis of experiments. The section is at present accommodated in the Department of Statistics of the University of Aberdeen, where it has the advantage of close contact with the A.R.C. Unit of Statistics, directed by the head of the Department, Dr. D. J. Finney, F.R.S.

PLANT BREEDING INSTITUTE

The Plant Breeding Institute at Trumpington, Cambridge, is a young organisation inheriting an old tradition. When legally constituted in 1952, with its own Governing Body, it took over the work and staff of the Cambridge University Plant Breeding Institute, which was the nucleus round which it has grown. The original Institute was set up in 1912, within the School of Agriculture of the University, under the direction of R. H. (later Sir Rowland) Biffen. It had a very small staff, and its work was at first confined to wheat and barley; but it soon built up a high reputation for genetical research and practical crop improvement. By the end of the second World War it had expanded enough to include some work on most of the more important arable crops, but was still a small organisation.

Post-war plans to intensify the national effort in agricultural research called for greater increases in staff, land and buildings for plant breeding than could conveniently be provided within a University. Accordingly, with the full agreement of the School of Agriculture, a new organisation was formed to acquire and develop a new site, and in due course to take over the work—which meanwhile continued uninterrupted. In anticipation of enlarged facilities recruitment of additional staff began in 1947.

The Plant Breeding Institute now employs at Trumpington a total (including office, maintenance and field staff) of more than 70 people. The Director is Dr. G. D. H. Bell. The scientific staff comprises 18 in Scientific Officer grades, 8 in Experimental Officer grades and about 30 Scientific Assistants. The laboratories are adequate in size and well-equipped; there is ample land to meet all foreseeable requirements; and glasshouses covering more than half an acre have been provided for the considerable part of the work that has to be done under glass.

The objects of the Institute, in the briefest terms, are to produce new varieties of crop plants and to develop new breeding methods. Thus, like other agricultural research institutes, it combines work applied directly to farming problems with a search for new knowledge which may be applied in the future. The crops studied are all the main field crops of English agriculture, the breeding of horticultural crops being left to the several horticultural research institutes.

The practical objects of any breeding station are inevitably influenced by the climate and agriculture of the region in which it is situated. In producing new varieties, therefore, the Institute at Cambridge concentrates on the needs of the drier and more southerly parts of Britain, leaving those of the west and north to receive special attention at the Welsh Plant Breeding Station at Aberystwyth and the Scottish Plant Breeding Station at Pentlandsfield near Edinburgh. The three centres co-ordinate their programmes carefully.

In all matters connected with the testing and distribution of its new varieties, and the maintenance of nucleus stocks, the Institute co-operates closely with the National Institute of Agricultural Botany and through that organisation it enjoys facilities for growing and observing breeding material at regional centres in Yorkshire, Norfolk and Devon.

A close and mutually beneficial association is maintained with the University of Cambridge. Senior members of the Institute's staff take part in University teaching, and the Institute is recognised by the University for the training of students registered for the Ph.D. degree. The Institute also provides postgraduate training for Colonial Office probationers and others intending to practise plant breeding overseas. Its services in that respect, over many years, have been outstanding and have contributed greatly to crop improvement in colonial territories and elsewhere. Visiting research workers are received from many Commonwealth and foreign countries.

The Institute has recently begun to publish annual reports on its work. The first, which covered the year 1958-59, contained a review by the Director of the development of the Institute as well as accounts of the many researches in progress.

RECENT DEVELOPMENTS AND OUTLOOK

The Council's Visiting Group of 1954 found the Institute still in a state of transition, with the new building not quite ready for occupation (it was officially opened in 1955) and most of the staff recently recruited. The Visiting Group of 1960 saw it fully settled into the new quarters, and reported a notable extension and consolidation of the research programme. The Institute has not yet reached the limit of its planned development, but has virtually completed one important phase. Nearly enough Scientific Officers have been recruited to cover adequately the main lines of the programme. They have acquired experience of their crops and problems, and have developed and tested new methods. As the result of good foundation work they are now in a position to employ more assistants, and so to handle a great deal more breeding material with correspondingly greater chances of practical successes. The further growth of the Institute during the next few years is therefore likely to be mainly in the addition of more Experimental Officers and Scientific Assistants to exploit the technical advances already made, while the senior staff continue to break new ground.

The breeding of agricultural crops is a long-term business. With cereals, for example, at least twelve years elapse between the making of a cross and the marketing of any new variety that may result from it. The Institute has already had notable successes from work begun in earlier years, but is only just entering the period when the results of working on a larger scale may be expected to become apparent in the form of increased output of new varieties.

THE RESEARCH PROGRAMME

The Plant Breeding Institute has responsibilities in the general field of crop improvements which cannot be met entirely by producing new varieties of the crops it handles. As a research institute it has been staffed and equipped for appropriate investigations of crop productivity and quality, and is expected to pursue scientific knowledge that will enlarge the possibilities of plant breeding everywhere.

The research policy is therefore framed to meet two distinct but related needs—the need for better crop varieties and the need for more knowledge of the best ways to get them. The practical and scientific aims are not incompatible. Breeding programmes are based on the requirements of agriculture, and cannot be chosen for their scientific interest; but the

breeding of a new variety to meet specified needs is a scientific problem and is approached as such. The difficulties frequently encountered in reaching practical objectives show where more fundamental knowledge is most needed. It is then the duty of a breeding organisation which is also a research organisation to go after the information required.

Pursuing this principle, the officers in charge of breeding programmes are also engaged in research, often using their breeding material for two purposes at once. Their research may be into breeding methods and techniques appropriate to the crop being bred, the inheritance of particular characters in the material, physiological characters influencing yield or earliness, or problems of quality in the product. For the study of some of the fundamental sciences underlying breeding it has been found desirable to add a few specialists who are less directly engaged in crop improvement and give their whole attention to research.

The research staff are organised with a minimum of formality into sections. The four main sections are plant-breeding teams, responsible respectively for cereals, potatoes and kales, sugar beet, and forage crops and grasses. Ancillary sections are cytogenetics, plant pathology, biochemistry and chemistry.

A few salient features of the work in progress are mentioned in the following paragraphs under headings corresponding to the sections. The many and various ways in which crop improvement is sought are set out in detail in the Institute's published reports.

Cereals. As befits their importance in British agriculture, the cereals have the largest team allotted to them. They are treated for practical purposes as six distinct crops, separate programmes being followed for the winter and spring varieties of barley, wheat and oats.

The Institute has had its most conspicuous successes with spring barleys, especially with the variety Proctor which was put on the market in 1953 and now occupies the bulk of the barley acreage of the country. Proctor was, of course, a product of work begun several years before the expansion of the Institute. Subsequent work has attempted to improve on it in earliness, straw strength and disease resistance without sacrifice of malting quality. New varieties now in trials include the first malting barley bred in this country that shows a high level of resistance to mildew. Concurrent effort has been directed to improving the winter hardiness of winter barleys and to testing the possibility of developing special higher-yielding barleys for feeding purposes.

In wheat breeding the primary aim is high yield, but much attention is given to grain quality, which includes both milling quality and suitability for either bread or biscuit-making. Special facilities have been provided to study, and test for, grain quality. Improved disease resistance is also sought. The wheat breeders have been specially active in developing new methods of selection and testing, with the object of improving efficiency and saving time between the initial hybridisations and final trials. Developments in wheat-breeding methods are reviewed in the Institute's annual report for 1959-60.

Oats receive less attention at Cambridge than barley or wheat, because they are less important in eastern England and large oat-breeding programmes at the Welsh and Scottish Plant Breeding Stations cater for other

regions. The Institute concentrates on two problems appropriate to its location—the improvement of yield in winter varieties and the breeding of spring oats adapted to the dry conditions of East Anglia.

Potatoes and Brassicas. The potato-breeding programme has recently been extended and revised. Efforts directed over many years to breeding for resistance to late blight, using *Solanum demissum* as the source of resistance, have had only limited success, either at Cambridge or at other potato-breeding centres. The attack on the blight problem has therefore been switched to new lines, trying to exploit a different kind of resistance found in other sources. At the same time, breeding for resistance to eel-worm (begun in 1952) has been intensified. A new programme has also been started which aims at combining good field performance with better culinary qualities than those of the variety Majestic which is now most widely grown in England. The various fungal and virus diseases to which the potato is subject make desirable combinations of resistance, yielding power and quality difficult to achieve ; but progress is being made.

Some work on marrow-stem kale was started by the potato-breeding team in 1950, and more recently thousand-head kale has been added. The first requirement was a genetical study of the breeding system to discover the best breeding methods. This has been completed. Varieties of marrow-stem kale are now being produced which are uniform for type and specially suited to particular forms of management and utilisation, such as strip grazing.

Sugar beet. The emphasis in sugar beet breeding has been on producing a variety highly resistant to bolting if sown early, and on finding sources of resistance or tolerance to the complex of diseases known as virus yellows. The first object was achieved when the variety Cambro was put in the market in 1959, though work continues to improve the stock. The second project has also had success to the point that tolerant material is now in hand for working up into commercial varieties. Concurrently the section has done valuable virological research, distinguishing between the various viruses and strains involved and determining their distribution. Other projects are the breeding of varieties with single-germ seed clusters, and investigating the application of hybrid vigour, male sterility and polyploidy to beet breeding. By arrangement with the Council, the work of the sugar beet section is financed by the Sugar Beet Research and Education Committee.

Forage Crops and Grasses. The older lines of research in this section are on field beans and lucerne. That on field beans has reached a critical stage. It has long been appreciated that more reliable and better yielding varieties would be an important contribution to English farming, but attempts to breed them by all the accepted methods have given disappointing results. Studies of the reproductive processes in beans have, however, suggested an approach, new for this crop, through the use of hybrid seed produced on inbred lines. This method is now being tested. If it fails to achieve a substantial increase in yield, the effort devoted to beans may be diverted to some more rewarding crop. The investigations of lucerne are aimed at producing improved types for various uses (short leys, long leys and pasture) and at incorporating resistance to *Verticillium* wilt and

stem eelworm. This crop also is being studied genetically with the object of improving breeding methods.

The breeding of grasses is the most recent major addition to the Institute's programme. The objectives were carefully chosen in relation to the long-established and extensive work at other centres. They are limited to meeting the requirements of the drier areas of the country, where low temperature in winter and low rainfall during the growing season make difficult conditions for the growth of grass.

Cytogenetics. This section is an offshoot of the cereal breeding, established to develop cytological studies of hybrids between different species of *Triticum* and between *Triticum* and related genera. It provides an excellent example of the dependence of technical advances on fundamental research; for its work on wide crosses (particularly between wheat and rye) has recently opened up exciting possibilities of quite new methods of wheat breeding, likely to have far-reaching results.

Plant Pathology. The increasing preoccupation of plant breeders with resistance to common diseases of their crops, and the need for specialist help with some pathological problems, led to the addition of this section in 1955. Its work has so far been primarily concerned with fungal diseases of the cereals and, in particular, mildew of wheat, barley and oats; yellow rust of wheat; loose smut of wheat and barley; and eyespot of wheat. Among other results, methods of testing for resistance to these diseases have been improved considerably.

Biochemistry. Comparative biochemical studies of crop plants in close association with plant breeding may be expected to produce information about biochemical differences among breeding material which will both add to fundamental knowledge and facilitate breeding programmes. The research of this section, which is at present concentrated on nucleic acids, has helped considerably in the study of the beet yellows virus complex.

Chemistry. The Chemistry Laboratory was set up as a service section to do routine analysis for all the crop-breeding teams. It does thousands of determinations a year of such components as nitrogen, oil, ash and fibre in cereals, potatoes, legumes, kales and grasses, providing information essential for the efficiency of the breeding. In addition, the chemist has undertaken special investigations of malting quality in barley, and has devised a new micromalting test which has not only proved useful to the breeders but also has been adopted by maltsters and brewers.

ROTHAMSTED EXPERIMENTAL STATION

GENERAL INTRODUCTION

Rothamsted is not only the oldest and largest of the State-aided institutes in the agricultural research service, but it also brings the widest range of scientific disciplines to bear on the agricultural problems connected with soils and the growing of crops. Though for many years after its foundation concerned almost exclusively with soils and fertilizers, the Station has added so many other interests over the last forty years that the researches directed primarily to those subjects now employ barely one-third of the total scientific staff. There are indeed slightly more

workers studying plant pests and diseases than there are in the soil departments, and other subjects collectively engage as many. However, the widening of interests has not been at the expense of work on soils; the soil departments themselves have grown and multiplied, and Rothamsted is still one of the leading institutes in the world in its original field.

The range of interests of the Station has been determined partly by its own history and partly (especially in later years) by the development of the agricultural research service as a whole. The original interest in soils and fertilizers broadened naturally into plant nutrition and other aspects of plant growth, but it has not extended into plant breeding, because of the existence of other centres specializing in that subject. Similarly, the parallel development in this century of horticultural research stations has allowed Rothamsted to devote most of its attention to farm crops, though there is no formal restriction on its choice of material for research. The evolution of strong departments in several subjects has been due to outstanding contributions to agricultural science by individual members of staff, which have attracted support on account of their evident practical value.

The research staff now consists of approximately 100 officers of the Scientific Officer class, 60 of the Experimental Officer class, and 150 of the Scientific Assistant class. The twelve departments into which they are organised provide convenient headings for describing the research programme, but no department is self-contained. Their interests interlock, many of their researches are collaborative efforts, and each department's programme is discussed in detail by the Staff Council. The nature of the Station's researches makes collaboration essential. The general policy is to undertake work with two connected but different objectives. Some of the work is directly aimed at solving current agricultural problems, and some is intended to derive explanations and establish principles. An example of the first is the comparison of effects on yield of different kinds of nitrogenous fertilizers; an example of the second, the general study of the causes of soil fertility. The second objective may not be stated explicitly in the programme of any one department, but it is implicit in the work of several; and such a many-sided subject as soil fertility demands the co-ordinated attack of different specialists each supplying his own contribution to a general picture. To take only one other example, most of the departments at Rothamsted are interested more or less directly in the effects of weather on crop growth and yield and on the incidence of pests and diseases. This is another complex subject, beyond the powers of a single specialist department to handle effectively, but one which is yielding gradually to collaboration by workers in physics, chemistry, and several branches of biology.

The work of Rothamsted provides an excellent example of a good balance between the attention paid to practical problems on the one hand and longer-term research into principles on the other. There is in practice no sharp division between the two kinds of work. Often both are being done by the same people and one experiment often provides information helpful to both objectives.

CHANGES AND DEVELOPMENTS BETWEEN VISITS

Rothamsted received Visiting Groups in 1953 and 1960. Between those dates, in 1958, Sir William Ogg retired from the Directorship, and was succeeded by Mr. F. C. Bawden, F.R.S., formerly a Deputy Director and Head of the Plant Pathology Department. There were changes also in the leadership of several of the departments consequent on retirements or on acceptances of senior University appointments.

The staff increased, but less rapidly than in the decade before 1953, when it more than doubled. In 1953 there were 92 members of Scientific Officer class and 45 of Experimental Officer class. There have thus been more additions in recent years in the latter class than in the former. Both trends—that towards a slower rate of growth and that towards a higher ratio of Experimental to Scientific Officers—are likely to continue. Though there is no general agreement on the optimum size of a research institute, it is apparent that the rapid increase in the past has caused considerable difficulty, especially by outrunning the rate at which the necessary accommodation could be provided. Growth in the next few years is therefore expected to be in buildings rather than staff, as far as possible new lines of work that are needed will be done by shifting the interest of existing staff in the Scientific Officer class. The provision of more laboratory space will affect staff ratios because, when space is limited, Scientific Officers may have to work without the assistance that would increase their output, and this must be put right by appointing more Experimental Officers and Scientific Assistants. Also, the amount and complexity of apparatus used in research continually increase, so that more people are needed, both to look after it and to use it fully. It is impossible for a research station to be wholly static; the important consideration is that the growth necessary to cope with increasing demands for research should be controlled and balanced so as to make the best use of manpower.

THE RESEARCH PROGRAMME

The outlines of departmental programmes presented here have been compiled partly from the papers prepared for the Visiting Group and the Group's report, and partly from the annual report of the Station for 1960, to which readers are referred for further details.

In these outlines, most emphasis has been laid on the longer-term objectives of the departments and no attempt has been made to mention all the many items under study. From their nature, the long-term objectives rarely change, and therefore the current programme, stated in general terms, may look very like the programme of several years ago. In detail, it will be quite different. While the main objectives do not change, the methods of attaining them do—for a variety of reasons. Emphasis may be shifted from one line of attack to another because an urgent practical problem calls for more attention, because a new discovery or technique suggests a more profitable approach, or simply because sufficient results have been obtained along a certain line of enquiry and attention can be diverted to something new. To record such changes of emphasis is one of the uses of the Station's annual reports.

Physics. The Physics Department, under Dr. H. L. Penman, is studying the two environments of the crop plant—above and below the soil surface—and aiming at an understanding of them which can be used to predict,

and partially to control, the effects of weather and soil characters. The programme is thus divided between agricultural meteorology and soil physics.

The department is most widely known for its long-term work on irrigation and the calculation of irrigation needs from the ordinary records kept by weather stations. Many of the increasing number of farmers who use irrigation are guided by a technical bulletin published by the Ministry of Agriculture in 1954 and largely based on earlier Rothamsted work. An irrigation experiment was begun at Woburn in 1951 and is now on its fourth three-year cycle. It was designed to find out how various farm crops react to watering at rates calculated to make good deficiencies in rainfall, and has yielded a great deal of practically useful information. At the same time the experiment has provided invaluable material for studies of the dependence of plant growth and crop yields on the weather, which interest more than one department at Rothamsted.

The background to the work on practical aspects of irrigation is an intensive fundamental study of the microclimate in field crops. The microclimate, or actual conditions round the individual plant, is of course related to the weather; but the relationship is complex and varies from crop to crop. Information essential to biologists studying plant growth or the behaviour of pests and plant diseases can only be obtained by systematic recording of daily as well as seasonal fluctuations with a high degree of accuracy. The measurements made include temperature, humidity and wind profiles in and above the crops, and radiation intensities at various levels. The recent addition of observations on carbon dioxide concentration gradients extends the applicability of the records beyond the study of water use to that of growth.

All this is dependent upon the use of suitable instruments, and the design of apparatus for accurate measurement and recording of the physical quantities under study is an important part of the department's activity.

On the soil physics side, attention is at present concentrated on soil aeration and the movement of water in unsaturated soils. These are two related aspects of the more general subject of soil structure, and both bear on the supply of water to the growing plant and so connect with the main topic of water use by crops. The state of knowledge of soil aeration is such that it has been necessary to start with fundamental studies of gaseous diffusion in a wide range of dry porous materials, by which a foundation has been laid for work on soils and the effects of wetting on pore space and diffusion. The aim is to get a quantitative measure of aeration; to decide, if possible, what it ought to be for optimum crop growth; and to see how near to optimum it can be brought by soil management. With water movement, the initial step has been to distinguish between movement as liquid and movement as vapour. Looking ahead, both these researches may be expected to contribute to understanding what is meant by good drainage in relation to crop growth.

This department faces some of the most challenging problems in agricultural science, holding almost certain promise of rewarding discoveries from well planned researches; yet in numerical strength it is one of the smallest departments of Rothamsted. This position reflects a difficulty in attracting good students of Physics to the agricultural research service,

which causes the Council some concern. The numbers required are not large, but for a selected few the service can offer prospects as bright as any of the more glamorous fields of physical research—and it is most desirable that this should be known.

Chemistry. The Chemistry Department, under Dr. G. W. Cooke, investigates chemical aspects of soil fertility that affect crop production. Mainly it is concerned with the chemical elements that are plant nutrients and, in line with the original purpose of Rothamsted, devotes a great deal of attention to the efficient use of chemical fertilizers. At the same time it does not neglect physical and biological processes in soil that affect crop nutrition. In particular it has been working for many years to elucidate the significance of organic matter in soils and the part played by organic manures in maintaining soil fertility. This fact needs to be stressed because, although soil organic matter is given a leading position in the department's annual reports, Rothamsted's contributions on this subject tend to be overlooked in quarters where contrary opinions are strongly held.

Current work on soil organic matter includes laboratory studies in which radioactive tracer techniques are used to follow the decomposition of plant material in soils and the rate of release of nitrogen at different stages of decay. It also includes field experiments to examine the effects of farmyard manure and of crop residues in an endeavour to separate nutrient and physical actions, which has so far proved difficult.

The major plant nutrients are studied from two points of view—their nature and properties as they occur naturally in soils, and the effects on the yield and composition of crops of supplies added as manures and fertilizers. The first links directly with the work on organic matter, with which the nutrients are commonly associated. The *nitrogen* status of soils, for example, is determined by rate of release from organic matter, movement in the soil and losses by leaching and denitrification. All these aspects are being investigated, as well as the uses of different forms of nitrogenous fertilizers to supplement the natural supply. *Phosphate* problems are especially those of the building up of soil reserves and the measurement of availability. Here again research on soil phosphorus is linked with studies of various phosphate fertilizers, and the radioactive isotope ^{32}P is used to trace both the building up of residues from fertilizers and the reactions between phosphate ions and soil constituents. *Potassium* also presents problems of availability, which has recently been shown to be related, in some soils at least, to the amount of fine clay present and the level of potassium in it.

Little is known about the total reserves of *magnesium* in British soils or of the amounts that are useful to crops. As reports of magnesium deficiency in crops on certain soil types are common, the department has begun an investigation to determine the nature, importance and properties of soil magnesium. The amount of the element removed by crops in the long-period experiments at Rothamsted and Woburn is also being measured. Watch is likewise kept on the amounts of some of the micro-nutrient elements, such as copper, manganese, molybdenum and zinc, removed by crops.

Work on fertilizers covers on the one hand investigation of the fertilizer needs of farm crops and, on the other, the comparison of different forms of fertilizers. As many field experiments are now done by the National Agricultural Advisory Service and by commercial firms, there is little need for this department to take a major part in standard experimental work testing the effects of manures and fertilizers on crops. The aim is rather to pioneer new types of experimental work with fertilizers, and with methods of applying them. A few years ago the emphasis was on placement methods, and results showed that considerable economies could be effected by suitable placing of fertilizers in proximity to plant roots. Knowledge of this technique is now ahead of practice, and for the time being the research has been stopped. The present emphasis is on the effects of crop rotation and of leys on the fertilizer needs of crops.

For many years the department has tested alternatives to standard fertilizer materials, keeping in touch with developments in the fertilizer industry. At present there is a tendency for compound fertilizers to become more concentrated, with practical advantages in manufacturing, transport and distribution. The new materials are compared, as they become available, with the older standard materials. Watch is also being kept on possible developments in the use of fertilizers in solution, by making small plot experiments comparing applications in solid and liquid form.

Some research on the soils of forest nurseries, done in collaboration with the Forestry Commission, fits into the general programme by providing soils of low fertility and other special conditions which are useful in comparison with agricultural soils and for various experimental purposes.

Pedology. Most of the work of the Pedology Department is only indirectly applicable to practical agricultural problems, its main function being to obtain fundamental knowledge about soils and soil-forming processes which may be used in various ways by other soil scientists with practical ends in view.

The head of the department, Dr. A. Muir,* is also head of the Soil Survey of England and Wales (which is based on Rothamsted) and a Deputy Director of the Station. The association with the Soil Survey brings the Pedology Department into close contact with problems of soil genesis and classification which provide a unifying theme for several specialist activities, while the Survey itself affords a link with agricultural practice.

The department studies rock weathering as an initial stage in soil formation, and for this purpose uses material from overseas (principally Africa) as well as from this country. It has, for historical reasons, a bias towards the mineralogy of clays, which are investigated by X-rays, electron diffraction, and physico-chemical methods. The various methods employed are directed partly towards the identification of clay minerals in soils, partly to the study of swelling and shrinkage of clays, and partly (by hydrothermal synthesis at high pressures) to reaching an understanding of how the clay minerals have been formed in nature.

* Died 1st February, 1962.

Another aspect of soil development under study is the effect of water-logging on flooded soils. It has been shown that plant materials, such as fallen leaves, have a strong influence on the movement of iron and other elements in waterlogged soils beneath and the effect has been traced to the action of polyphenolic substances leached out of the leaves. Work is now planned to study the reduction of sulphate in waterlogged soils.

The department is equipped for spectrochemical analysis and is surveying the occurrence and distribution of trace elements in soils derived from sedimentary rocks. It also does spectrochemical analyses for other workers at Rothamsted and elsewhere. Recently, for example, it has examined soils and crops from plots that had been treated with sewage sludge suspected of being contaminated with heavy metals from industrial waste.

Soil Microbiology. Among the diverse activities of micro-organisms in the soil, which are much too numerous to be studied by one department, those selected to receive the most attention by the Soil Microbiology Department under Dr. P. S. Nutman are those affecting the nitrogen cycle—a subject of great importance in agriculture. Dr. Nutman himself is known as a leading authority on the nodulation process by which leguminous plants, in symbiosis with micro-organisms of the genus *Rhizobium*, are able to fix atmospheric nitrogen and so add to the useful nitrogen content of the soil in which they are grown. This process has been studied in all its aspects for many years, but still presents many problems of practical significance; especially in connection with the variability between strains of *Rhizobium*, some of which are quite ineffective in fixing nitrogen while others vary in their effectiveness. Variation in the legume host is another factor to be taken into account, both between species and within each species commonly used in agriculture. There is still more to be learned about the process of infection of the legume root, and about what goes on, biochemically, within the nodule. All these aspects are being investigated.

Another part of the nitrogen cycle in soil is that depending on two genera of bacteria, *Nitrosomonas* and *Nitrobacter*, which working together oxidise ammonium compounds to nitrate. For thorough studies of these bacteria it is desirable to be able to grow them on a fairly large scale in pure culture, which is difficult. The department has been working on a technique for growing *Nitrosomonas* in continuous culture and has achieved a degree of success which opens the way to more extensive investigations.

Many soil micro-organisms are able to fix nitrogen, though their significance in adding to the total nitrogen supply is not known. Attention has lately been drawn particularly to one of them, *Azotobacter*, by Russian claims that crop yields can be increased by inoculating seeds with it. Many acres in Russia are sown annually with seed treated with so-called bacterial fertilizers, but few results have been published that allow the value of the treatment to be assessed critically. The department has therefore made some preliminary experiments, with results that are both interesting and puzzling. They show that seed inoculation can produce very high

populations of *Azotobacter* around the roots of the plants, but the effects on growth are erratic. In field experiments little effect on yield was found. In pot experiments inoculation sometimes greatly increased growth and sometimes had no significant effect on growth although it still gave high populations along the roots. Evidently a great deal more work will be required to discover the precise conditions under which seed inoculation stimulates growth, and until those conditions are defined it will be impossible to predict whether the operation is likely to have any practical use in agriculture.

Although these and other aspects of the nitrogen cycle account for a large part of the department's work, other investigations are also going on. The activities of soil micro-organisms include the breaking down of various materials added to soils. There are, for example, the anaerobic bacteria which decompose cellulose in soil and organic wastes, starting a series of reactions which end in the production of a gas rich in methane. These are being studied in relation to the practical possibility of producing methane by fermentation of agricultural wastes, a subject which is often discussed, though the microbiology of the process is little understood because of the difficulty of isolating and maintaining pure cultures of the organisms concerned. Work has also been done on the breakdown of herbicides, of synthetic oestrogens, and of certain detergents. The need for investigations of this kind continues as new substances are brought into agricultural use.

The background to all the work of the department is a general knowledge of the biology and ecology of micro-organisms in the soil, which has to be built up by a variety of studies not directed to specific practical ends. Techniques for counting, isolating, and identifying organisms have continually to be improved. One region of the soil of particular ecological interest is the immediate neighbourhood of the plant root (the rhizosphere) where microbiological stimulation is partly due to the exudation of substances from the growing root. Study of the rhizosphere produces its own problems of technique.

Botany. The programme of the Botany Department, under Dr. D. J. Watson, is concerned with two general topics—the physiology of crop growth and yield, and the biology and ecology of weed species.

The object under the first heading is to analyse the behaviour of crop plants in the field so as to find out in detail how they build up yield. The study of the reactions of the plants to various husbandry practices (a largely controllable element in the environment) and to weather (an uncontrollable element) is implicit in the analysis; and in seeking a better understanding of the plant environment and its effects, the Departments of Botany and Physics have many common interests leading to collaboration.

The basic technique used is the form of growth analysis which follows, throughout the life of the plant, or for such shorter periods as may be appropriate, the changes in the size of its photosynthetic system (leaf area) and in the efficiency of the system as measured by increase in dry weight (net assimilation rate). Work along these lines has established the

pattern of growth of different field crops at Rothamsted, and is continually being applied to more species. It has shown, among other things, that as the leaf area per unit area of land increases the net assimilation rate decreases. This is presumably due to increased mutual shading of leaves, and it sets limits to the possibility of increasing yield by increase in leaf area; but an interesting point is that the effect varies between different species of crop plants, according to the extent to which the arrangement of their leaves leads to mutual shading.

The method has been, and is being, applied in experiments to find physiological explanations for changes in yield caused by varying husbandry practices. For example, it is helpful in explaining the nature of competition between plants within a crop and the effects of different spacings. It is also being used to analyse the effects of water stress and irrigation at different periods in the development of sugar beet and barley. In its application to cereal crops it has brought out the significant fact that a considerable proportion of the carbohydrates in the grain is the result of photosynthesis in the ears, barley ears contributing about 25 per cent. and wheat ears 15 per cent. of the grain dry weight.

Because field studies have shown the overriding importance of leaf area in determining yield, factors that influence leaf number, size, and longevity are being studied in the laboratory. The possible role of specific substances in controlling leaf expansion is being investigated, partly by testing the effects of known growth-regulating substances such as gibberellic acid and kinetin, and partly by attempting to isolate growth substances from expanding leaves.

In researches on weeds, species are selected mainly on grounds of their current agricultural importance. The programme is not concerned with herbicides, except in relation to their long-term ecological effects, but is directed to finding out how infestation occurs and in what way and how much weeds affect crops. Until recently, most work was done on wild oats; at first because they were a Rothamsted problem and later because they have become the most troublesome weeds of arable land. The department probably now has more knowledge of these weeds than any other centre in the world. Emphasis is shifting to studies of competition between crops and weeds, and the competitive effects of several common weed species.

Biochemistry. The Biochemistry Department, under Mr. N. W. Pirie, F.R.S., is working on four main topics—leaf protein, plant enzyme systems, viruses, and eelworm hatching factors.

Mr. Pirie's well-known work on the extraction and use of leaf protein is inspired by the fact that in many of the less-developed countries the supply of protein is insufficient for proper nutrition of the people, and by the forecast that, as the human population grows, protein is likely to become increasingly scarce and dear. The protein content of most vegetable foodstuffs, except the pulses, is low; and protein-rich animal products such as meat and milk are expensive in terms of the land requirement of the animals producing them. At the same time large quantities of protein go to waste, from the point of view of human nutrition,

in vegetable materials unsuitable for direct consumption by man. This leaf protein, when extracted and suitably processed, is useful and the potential supply is great. Over many years Mr. Pirie has devised and improved methods of extraction and processing, and latterly has given attention also to the presentation of the protein in palatable forms and to methods of packing it for year-long storage. This work, which has been assisted by a grant from the Rockefeller Foundation, has reached a stage when the process for bulk preparation can be handed over to some other authority for development, probably overseas in the wet tropics where suitable leaf material is most abundant. Laboratory work on factors influencing extraction of protein, and on the suitability of various plant species for the process, will continue.

Research on plant enzyme systems is also of long standing in the department, and makes fundamental contributions to plant physiology. Enzymes currently under study include amine oxidase, chlorophyllase, protease and thiaminase.

Collaboration between this department and Plant Pathology in the study of plant viruses has been very fruitful in the past, and continues. The subject immediately under investigation is the process of multiplication of tobacco mosaic virus in infected leaves.

Work on eelworm "hatching factors" or "root diffusates" is, by comparison with the other subjects, new in this department though it has been going on for several years. These hatching factors are chemical substances which, produced by the roots of the host plant, stimulate the dormant cysts of parasitic eelworms in the vicinity to hatch. Exact knowledge of their constitution would be a great advance in fundamental knowledge, with possibilities of practical application; but technical difficulties have hitherto prevented a complete analysis. One formidable difficulty lies in getting enough of the substance in a pure state from the extremely dilute solution in which it is obtained from the plant. Several tons of potato-root diffusate (supplied by the Nematology Department) have already been concentrated and put through the preliminary stages of purification in the attempt to identify the hatching factor of potato root eelworm, and the work is not yet completed, though it now shows promise of a successful outcome. Similar work on the hatching factor of the beet root eelworm is proceeding simultaneously.

Plant Pathology. The Plant Pathology Department is one of the largest at Rothamsted, and the largest of a group of four departments concerned with the pests and diseases of crop plants and their control. It was formerly under the present Director of the Station and is now led by Dr. P. H. Gregory. The researches in progress are directed partly to solving specific practical problems, but at least as much to elucidating general principles of plant pathology. As they cover both viruses and fungi, which demand somewhat different techniques of investigation, the programme falls naturally into two sections.

The department has an international reputation for its contributions to knowledge of plant viruses, of which practically every aspect of importance is receiving attention. Some of the most fundamental research deals with the structure of virus particles (studied by electron microscopy) and the

functions and properties of their component parts. Other fundamental studies are concerned with the factors that affect the susceptibility of plants to infection, the extent to which viruses multiply in infected plants, and the interactions between different virus strains when present in one plant.

Practical benefits as well as basic knowledge have come from such research. For example, the study of the effects of light and temperature on virus multiplication led to recognition of the possibility of heat therapy, now widely practised to obtain virus-free propagating material from infected varieties, especially of fruit plants.

More recently, another method of obtaining virus-free material has been successfully exploited. For over 30 years King Edward potatoes have been known all to be virus-infected. Knowledge of the fact that some viruses do not invade the growing points of infected plants led to the experiment of excising apical meristems from King Edward potatoes and growing them on nutrient agar medium until one grew into a plant that could be propagated. It proved to be virus-free, and in the first field trials the stock built up from it has yielded 10 per cent. more weight of tubers than seven of the best obtainable stocks now being grown. Efforts are being continued to find ways of obtaining virus-free material from clonal varieties of crops infected with viruses which do invade the meristems and are not amenable to heat therapy.

Another aspect of virus research is into the ways that viruses are transmitted by animal vectors. Most of the viruses important to British agriculture are transmitted by aphids and much work has been done, and is continuing, on the mechanism of transmission and on the control of the diseases by control of the aphids (in 1959 it was estimated that the average yield of sugar beet was increased by 25 per cent. as a result of spraying to control aphids carrying yellows). New vectors of virus diseases are, however, continually being found; and so the work on methods of transmission has had to be extended to leafhoppers, mites, and—for certain soil-borne viruses—eelworms.

The department always has under investigation a number of specific virus diseases of minor economic importance as well as several of the major ones. The former are often not sufficiently important to command high priority for research, but study of them is useful in helping to build up general knowledge of the epidemiology of virus diseases and methods of control, and they are changed as frequently as the promise of learning more from them is exhausted.

Certain fungus diseases have been subjects of continuous and detailed investigation at Rothamsted for very many years, yet still pose unanswered questions calling for further work. These are some of the perennial problems of agriculture, to which there can be no simple answers because of the complex interactions between pathogen, host plant, weather and husbandry practices. Patient research upon them is neither a frustrated search for a simple answer nor a policy of despair. In fitting together, year by year, fresh pieces of the puzzle, the workers are gradually completing the picture. Meanwhile, if complete control of the disease is unlikely, the degree of partial control attainable increases with each forward step in knowledge.

The foot-rots and root-rots of cereals are diseases in this class. Those known as eye-spot and take-all are among the most important factors limiting wheat yield. Over forty years a great deal has been learned about them, and work goes on. It is known that preceding crops on the land often have more effect on the incidence of eye-spot than any other treatment. One problem among many is to find out how this effect is produced. This is a point at which plant pathology and soil microbiology come together.

Potato blight is another of the perennial problems. This disease provides excellent material for studying the effects of weather on infection, and has been used to that end. Past work has greatly improved methods for forecasting outbreaks and of giving warning of the need to spray, but further improvement is sought. Other work with potato blight is aimed at providing information helpful to breeders who are trying to produce resistant varieties. This is being done by analysing the mechanism of resistance in commercial varieties which show large differences in susceptibility and so discovering which morphological and physiological characters contribute to resistance.

A more general topic of investigation in the department is the dispersal of fungus spores in the air. Notable advances have been made in developing spore-trapping techniques, on which advice has been given to plant pathologists in many parts of the world. The connection of this work with other studies aimed at the forecasting of outbreaks of certain diseases and the timing of spray applications is obvious.

A relatively new line of research to plant pathologists is the study of the genetics of fungal pathogens. Genetical variation in the host plants is the basis of the work of plant breeders in producing resistant varieties, but too often their efforts are stultified because the pathogen is also variable, and produces new races able to attack the new varieties. This is just one aspect of the relations between parasites and hosts which provide a wide field for long-term research.

Nematology. Compared with plant pathology, nematology is a relatively young subject in agricultural science. Plant diseases caused by eelworms have been known for many years, but in the early days they were studied by pathologists without specialised training in what has now come to be recognised as a distinct and important branch of plant protection. The Nematology Department at Rothamsted, now under Mr. F. G. W. Jones, was set up as recently as 1947, and half the present staff have been appointed since 1956. Its early work was mainly on cyst-forming nematodes, especially potato root eelworm as one of the most serious agricultural pests in Britain. This continues to receive much attention, but the scope of the department has been widened as it has grown in size. In a rapidly growing subject, the programme must be carefully selected to avoid dispersion of effort over too many problems. The department is therefore concentrating along three main lines.

In the first place there is great need in the field of nematology for systematic studies on the identification and classification of plant and soil nematodes, which are far less well known than, for example, insects or fungi. Taxonomic information is basic to all other studies and therefore,

in the present state of knowledge, it is necessary for a research institute to do for this group the sort of work that is usually carried out in museums or other taxonomic centres.

The second main line of research is the study of the biology of parasitic eelworms and relations between them and the plants they infest. As these pests are soil-inhabiting, it is necessary to find out how they live, move and multiply in the soil and how they are affected by soil conditions such as structure, moisture and aeration. It is also necessary to find out how they invade their plant hosts, and the nature of resistance or susceptibility of the plant to attack. Mention has been made under Biochemistry of the hatching factors which are important in the life cycle of the cyst-forming nematodes. The Nematology Department is responsible for supplying the root diffusate for chemical examination and also for bioassay of the fractions isolated by Biochemistry.

The third subject for study, and the one with most directly practical aims, is control. Control measures may depend on finding resistant crop varieties, on cultural treatments, or on the use of chemicals. The first is not the direct concern of this department, but does affect it indirectly. For example, resistance to potato root eelworm has been found in a wild *Solanum* closely related to the cultivated potato and plant breeders are well on the way to producing resistant commercial varieties; but variants of the eelworm have been found which can attack varieties resistant to the common form. This poses a problem in host/parasite relations which is engaging the attention of the department.

Control measures based on cultural operations can of course be devised only from the knowledge of eelworm biology and host/parasite relations obtained in the second part of the programme. Control by chemical nematocides requires in addition a rather different approach. This line is also being followed, but is recent and has not yet had time to lead to any outstanding results.

Insecticides and Fungicides. This department, under Dr. C. Potter, is concerned, as its name implies, with the chemical control of plant pests and diseases and naturally has close connections with the Departments of Entomology and Plant Pathology. There is indeed no clear-cut division between their functions, as all are interested in control and chemical control is only one of several weapons in the plant protection armoury. Though the interests of the department are strongly chemical, they are also strongly biological. The work is much more on insecticides than on fungicides, and it is very largely on their mode of action. Its general practical objective is to improve the efficiency of chemical control in conjunction with other methods.

The mode of action of insecticides is studied both as it depends on the chemical constitution of the substance applied and as it is affected by the method of application. The important group of organo-phosphorus insecticides acts on esterases in the insect, and study of the mechanism has involved a biochemical investigation of insect esterases. This is linked with an attempt to discover how and why some insects develop resistance, which is one of the fundamental problems in insect control. The effects

of temperature, humidity and the immediate environment on the toxicity of a number of insecticides have been studied and this work continues.

When insecticides are used as seed dressings for the control of pests attacking the underground parts of plants, their effectiveness depends to a great extent on their persistence, which depends in turn on such factors as soil type and drainage as well as the formulation of the chemical. Absorption and movement of the chemical in the soil are followed by using insecticides labelled with radioactive isotopes. Persistence is also important when insecticides like D.D.T. are used to form residual films on plant or other surfaces, which kill insects alighting on them.

For many years the department has worked on the insecticides derived from plants, particularly derris and pyrethrum and especially the latter. Pyrethrum contains several different active constituents, and the basic chemical work has been in separating and purifying them for individual examination. This has been coupled with an investigation of the relationship between their chemical constitution and their toxicity, to obtain clues to their mode of action.

Much of the work of the department depends on precise methods of bioassay (the assessment of toxicity by lethal action on test insects) and much attention is therefore given to continual improvement of apparatus and techniques for this purpose. Techniques differ according to whether what is to be measured is direct contact action, residual contact action, or stomach poisoning. The rearing of suitable test insects itself involves some research.

Work in the field is directed to the control of specific crop pests. Recently these have included wheat bulb fly, mustard pests, the vectors of potato viruses and the black bean aphid on field beans. Watch is also kept on the long-term effects of insecticides, with particular reference to their harmful effects on beneficial insects such as honey bees and other pollinators, and the insect predators and parasites of pest species. The aim is to integrate chemical and natural control in such a way that the harmful effects of insecticides are kept to a minimum.

Entomology. The Entomology Department, under Dr. K. Mellanby, C.B.E.,* completes the quartet of plant protection departments at Rothamsted which collectively comprise more than one-third of the total staff. Its title is not to be interpreted too literally as it works on plant pests and soil fauna including mites, millipedes, worms, slugs and other soil animals as well as true insects.

The department is much concerned with problems relating to insect populations, because it is only when a pest population reaches a certain level that it becomes damaging, and only at a higher level that the damage is enough to make control measures worth while. The background to most of the research on specific pests is therefore an attempt to discover how climatic and other conditions affect population increase. Studies of the migration and dispersal of insects also help to throw light on how infestation occurs.

* Dr. Mellanby resigned in 1961 to take a post with the Nature Conservancy, and has been succeeded by Dr. C. G. Johnson.

Among the true insects, the aphids have long had a prominent place in the programme, with special reference to their physiology, distribution and control. To study their movements, insect traps were operated at different heights in the atmosphere over ten years and a great deal of information was acquired about their daily and seasonal distribution in relation to weather. The traps caught various other insect species as well as aphids, and the factors operating in the mass migration of aphids were found to apply to migrant insects of other orders. Consequently a full analysis of the figures is making it possible to formulate general principles of insect dispersal. An interesting recent observation has shown that many small day-flying insects can easily and safely circulate up to several thousand feet before being deposited, unharmed, on a plant.

Specific pests under investigation at present include wheat bulb fly and frit fly, both pests on cereal crops. Studies of the damage to crops by both species are being made, and the work on frit fly includes observations of population changes aimed at making possible the forecasting of attacks.

The department has always been interested in soil fauna, but has recently increased its work in that direction. It has returned, after an interval of some years, to the study of earthworms.

Earthworms may form the greatest part, by weight, of the soil fauna, but their importance is still imperfectly understood. Work on this group includes studies of their activities in burying leaf litter in orchards and surveys of the population at different depths and seasons at Rothamsted with observations on their behaviour in relation to weather.

Slugs are one of the few pests for which there is no successful and cheap method of control on a field scale. They are also capable of doing considerable damage. Work has been in progress on them for several years and includes investigation of the life histories of several species and field assessment of damage to varieties of potatoes.

Bees. Rothamsted is the only agricultural research institute to have a Bee Department, though there are departments of beekeeping in some agricultural colleges. The department is led by Dr. C. G. Butler, who is an internationally recognized authority on bee behaviour. The research is mainly on the behaviour and physiology of honeybees but attention is also given to bee diseases and to bee breeding.

One of the outstanding achievements of recent years has been the recognition, and finally (with the collaboration of Dr. R. K. Callow of the National Institute for Medical Research) the identification, of "queen substance"—which can now be synthesised and produced in quantity. This is the substance produced in the mandibular glands of the queen honeybee, and shared among the members of the colony, which inhibits ovary development in worker bees and prevents them from rearing queens. It is thus the means by which the queen bee largely controls the activities of the hive. Its possible uses in practical beekeeping can now be tested.

From the agricultural (and horticultural) point of view the significance of bees is perhaps less as honey-producers than as pollinators. This aspect is not neglected by the department, which is studying the foraging

behaviour of honeybees and its effects on pollination. It has also studied bumble bees in the same connection.

Statistics. The Statistics Department at Rothamsted began with the appointment of R. A. Fisher as statistician to the Station in 1919. The event had much more far-reaching effects than had been foreseen, as it resulted in the development of new methods of design and analysis of experiments which have had revolutionary effects on all branches of agricultural research. Since 1933 the department has been under Dr. F. Yates, F.R.S., who is also a Deputy Director of the Station. Under his leadership the earlier work has been greatly extended, and the department is now one of the largest in the Station.

Although originally intended primarily to serve the needs of Rothamsted, the department has always had many outside contacts, and has assisted research workers in other organisations, both with advice and with the analysis of data. After the war its wider responsibilities were recognized by its reconstitution (still as an integral part of Rothamsted) as a "Research Statistical Service of the Agricultural Research Council and the Ministry of Agriculture". In that capacity the department, in addition to analysing the field experiments at Rothamsted, does the same for the National Agricultural Advisory Service and provides whatever advice and help may be needed by other institutes in the agricultural research service. It also gives services to Colonial territories.

The biggest advance of the last few years has been the acquisition, in 1954, of an electronic computer. This has led to a considerable re-orientation of the work, as the availability of a computer requires a new approach to many problems and makes practicable the handling of others which were formerly impossible. An article on the introduction of electronic computers in research statistics which appeared in the Report of the Agricultural Research Council for 1957-58 discusses their advantages. One result at Rothamsted has been that the speed and capacity of the computer have enabled the Statistics Department to accept an increasing load of computational work from other research centres. The number of replicated experiments analysed in a year has risen in consequence from 803 in 1955 to 3,772 in 1960, and the demand continues to grow. An order has been placed for a larger and faster machine which is expected to be installed about the end of 1962.

The department is able to assist others only as a result of its own continuous statistical research. The preparation of programmes for the computer is essentially research, and although the routine analysis of the results from any field experiments depends on principles established long ago, and can be standardised, much of the material that comes into the department is less straightforward. Constant research is therefore required to find the appropriate mathematical treatment for problems that cannot be handled by standard methods.

In addition to its work on the design and analysis of experiments, the department is involved in sample surveys of agricultural practice, which cover a wide variety of subjects. These surveys are usually carried out in collaboration with some other organisation which has facilities for the field enquiries, the co-operation of the Statistics Department taking

the form of designing the survey and analysing and reporting the results. Recent examples have included a number of animal disease surveys, which have yielded important information about the national incidence and relative economic importance of disease in farm animals.

Field Experiments. Field experiments on the farms at Rothamsted and Woburn play an essential part in the research of all departments. They include the Classical experiments which have been maintained since the foundation of the Station, long-period rotation experiments, and short-period experiments. The total number to be looked after in any year is about 60, with more than 3,000 plots to be harvested individually. Careful organisation is therefore necessary. The programme is controlled by a Field Plots Committee of members of the scientific staff, and a small Field Experiments Section provides day-to-day liaison between the scientists and the farm staff, keeping members of the various departments informed about farm operations affecting their experiments and observations.

This section also receives many of the several thousands of visitors who come to Rothamsted during the year, either as individuals or in parties, and demonstrates the field experiments in progress.

Visiting Workers. Large numbers of scientific workers come to Rothamsted from all parts of the world to study and to learn new techniques or methods. In 1960 there were 76 such visitors, of whom 37 were from the United Kingdom and 39 from no less than 22 different Commonwealth and foreign countries. Some stay long enough to make substantial contributions to the Station's research. At the time of the Group's visits there were about 30 such long-term students dispersed among the departments. The Station and the Council strongly favour the practice, which is only limited (for suitably qualified people) by the accommodation available.

PEST INFESTATION LABORATORY

The Pest Infestation Laboratory, at Slough, is one of the three laboratories concerned with food research that were transferred in 1959 from the Department of Scientific and Industrial Research to the Council.

The Laboratory was set up in 1940 as a result of representations from the British food handling and processing industries, which at that time were seriously affected by the infestation of both raw and processed foodstuffs by insects. The war was then in progress and it was national policy to hold long-term security stocks of foodstuffs. This created ideal conditions for the development of very heavy infestations and in the early years the whole effort of the Laboratory was directed to research touching the protection of these food stocks.

Insects introduced in imported cargoes had established themselves widely in the warehouses and factories through which the foodstuffs passed, not to mention the lorries, trucks and barges in which they were transported. Clean, newly processed foodstuffs were therefore constantly exposed to the danger of cross infestation to the great concern of manufacturers and store keepers alike.

Research was started into the biology and rates of increase of the insect pests as well as into the development of safe and effective methods of disinfection. The results of this research were applied in practice by a unit set up by the Ministry of Food to deal with infestation control problems, which later developed into a Directorate of Infestation Control. There is no doubt that in this way very substantial losses of food were avoided. The Pest Infestation Laboratory in those days played a part also in the development of effective fly sprays for use by the Armed Forces abroad and its work must have contributed to the comparative freedom of the fighting services from insect-borne diseases in the last war.

When the war ended there were changes in a number of directions. The food industry gradually reverted to pre-war conditions and the purchasing and handling of foodstuffs came once again under private as opposed to Government control. The need for holding security stocks diminished, with the result that food stocks were more rapidly turned over; this in itself lessened the chance of build-up of serious infestations. Those concerned in the handling of food—shipowners, warehouse keepers, manufacturers and others—had also become much more alive to the threat of infestation than in pre-war days. Further, the Ministry of Food's Directorate of Infestation was taken over by the Ministry of Agriculture and Fisheries and reorganised as an Infestation Control Division, with, among other duties, responsibility for advising industry on practical measures for the control of insect and rodent pests of stored products and with a field staff of insect and rodent inspectors and provincial pests officers.* Lastly, many well organised servicing companies were established, capable of undertaking disinfection measures on a commercial basis. As a result of all these changes the Laboratory was relieved of much advisory work of the kind it did in its early years and it was able to concentrate more on a wide range of research problems.

One of the most important directions in which continuing research is now needed is on the chemical control of insect pests. Although great strides have been made in the development of effective insecticides, there is still need for their improvement in the direction of safety and efficiency. For example, the fumigant most commonly used today, methyl bromide, though highly toxic to insects, is even more toxic to man, so that it can be used only by specially trained operators under carefully specified conditions. Contact insecticides such as DDT, lindane and malathion can be used only at low concentrations on or near foodstuffs on account of the danger of contamination or taint; this severely limits their effectiveness, particularly against certain species of insects.

Another problem of great importance is the development of resistance to insecticides. This has already given rise to serious difficulties in the control of certain medical and agricultural pests and is now beginning to appear in some species attacking stored products. If it should develop substantially as the years go by, much of the progress in the field of chemical control, achieved over the last fifteen years, could be nullified.

* A more detailed account of the early history of pest control and of war-time developments and post-war reorganisation is given in the Ministry of Agriculture, Fisheries and Food's bulletin "Infestation Control".

For a proper understanding of the nature of resistance, physiological and biochemical studies are being made of the penetration of insecticides and on the mode of action within the insect of the chemicals concerned.

Fortunately there are other ways than by the use of chemicals in which infestations can sometimes be controlled. One direction in which important developments are taking place is that of new packaging and storage techniques. Besides the research in progress at the Laboratory useful advances have been made in recent years by industry itself.

There is another side to the picture which has lately been much stressed. Britain is dependent upon imported foodstuffs for her survival. Anything which adversely affects the quality or quantity of those foodstuffs is of direct concern to the British food industry and ultimately to the consumer. No pest control service, however efficient, can prevent the initial infestation of imported foodstuffs if it operates only at the receiving end. It is thus essential, in the interests of the British consumer, no less than of the exporting country, that every effort should be made to tackle the infestation problem all along the line, beginning in the producing country and including all transport, especially ships.

Recognising this, the Colonial Office set up a Stored Products Research Committee in 1948, on which the Laboratory was represented, and in 1951 appointed a Colonial Liaison Officer (now called Tropical Liaison Officer) at the Laboratory. The first duties of this officer were to investigate personally the conditions of food storage in certain territories overseas, to make an appraisal of the losses due to insect infestation and where possible to make recommendations leading to their reduction.

It soon became evident that the extent and intensity of insect destruction of stored foodstuffs in many tropical and sub-tropical territories was on a scale out of all comparison with that obtaining in the United Kingdom and other temperate countries. Fortunately this is no longer the case today. Overseas Governments are becoming aware that it is just as important to conserve foodstuffs after harvest as it is to protect the growing crops, and energetic measures are being taken in many territories towards this end.

The requests for technical advice and assistance that have come to the Laboratory as a result of these developments have been welcomed as widening the horizons and experience of the staff in the field of pest control generally. A number of visits have been paid, on a partial repayment basis, by members of the staff to advise overseas Governments on specific problems. It is of interest that control methods known to be effective in Britain have often been found much less effective or even quite inappropriate under tropical conditions. Some of the problems that have arisen have been investigated by a small research unit attached to the Laboratory, which is paid for by the Colonial Office. Others of a more general nature have usually already been under investigation in the programmes of one or other section of the Laboratory.

The wide experience of the Laboratory in all aspects of pest control in stored products has resulted in its receiving many visitors from various parts of the world. Some of them come, by arrangement, to work in the laboratories for periods of six months or more and the staff undoubtedly benefit from the daily contact and discussions with technical colleagues

from other countries. Close liaison is maintained with the Infestation Control Division at Tolworth of the Ministry of Agriculture, Fisheries and Food.

An annual report is published by Her Majesty's Stationery Office under the title "Pest Infestation Research" and this records, with illustrations, the details of many more investigations than can be referred to here.

THE RESEARCH PROGRAMME

The Visiting Group that went to the Laboratory in 1960 was the first appointed for this purpose by the Agricultural Research Council. They found a vigorous institute with an established reputation, working enthusiastically under the Director, Mr. G. V. B. Herford, C.B.E. The staff numbered 49 in the Scientific and Experimental Officer classes, together with a further 6 in a Tropical Liaison group supported mainly from Colonial Development and Welfare funds. It was noted that the Insecticide and Biochemistry Departments were housed in modern laboratory buildings completed in 1957 and 1958 respectively, but that the Biology and Fumigant Departments were still working under rather crowded and unsuitable conditions. However, plans are in hand for a new building to re-house these two Departments, together with the Library and Photographic Section as well as to provide an adequate conference room and a range of constant temperature and humidity rooms.

No more than a very brief outline can be given of the work in progress in the various departments, but this will serve to indicate the wide range of problems that must be studied in research on the control of stored-product pests.

Biology. The Biology Department studies all aspects of the life histories of the many pests that affect stored products and provides the essential basic information that is needed by other sections of the Laboratory in their studies of various control methods. The investigations range from field work to laboratory experiments and systematics, the last referring to the proper identification of the various pests, which is not always easy. The term "life history" covers the determination of rates of development, survival, reproduction and net increase of pests under controlled conditions of temperature, humidity and nutrition. The extremes of temperature and humidity beyond which a pest does not complete its development are referred to as the "physical limits" for that species.

There are some 60 common and important pests of stored products and as many again that are well known as minor pests. Information on their life histories may lead to new methods of control, as of the Carpet beetle by the removal of birds' nests from houses, or of the Khapra beetle by the quick cooling of malt; sometimes it suggests improvements in existing practice, as when the survey of insect populations in residues of foodstuffs in stores underlined the desirability of building such stores so that they provided no cracks or crannies where infested debris could lodge.

The field of work is so wide that it is not possible to cover the whole of it. Little or no work has been done yet on genetics, analytical dietetics, analytical physiology or pathology. However, it is hoped, within

the next six-year period, to start some work on the pathology of insects to see whether certain micro-organisms might provide a useful means of biological control.

Some of the pests under investigation at present are the Foreign Grain beetle, Copra beetle, three species of Flour beetle, Khapra beetle, Warehouse moth, several Grain beetles, Cigarette beetle and Flour mite.

Storage. The Storage Department studies the basic principles underlying the safe storage of cereal grains and other materials that can be stored in the dry state. Methods of measuring temperature and moisture in stacks of grain are investigated, as well as the design of storage bins and other containers suitable for different climates. The current programme includes a test on the long-term storage of grain, as well as experiments on the effect of storage under air-tight conditions in various types of storage structure. An article on the latter appeared in the last annual report of the Council. Particular attention is being given to the hermetic storage of damp grain, with collaboration from the Mycology Section in the study of microbiological changes, and to the air-tight storage of insect-infested dry grain as a means of killing the pests and preventing re-infestation, mainly for tropical countries. The latter study is being done in conjunction with the Biology Department. It is also planned to make a study of various plastic materials that might be suitable for the construction of storage structures and containers.

Mycology. Mycological work, originally begun in the Grain Storage Section, has now been transferred to the Biology Department. The main studies at present are of ways in which temperature and moisture affect the growth of the fungi that occur on stored products.

Insecticides. The Insecticide Department under Dr. E. A. Parkin, who is also Deputy Director of the Laboratory, seeks to evaluate insecticidal measures other than fumigants, which may be suitable for the prevention and control of infestation by stored-product and household insects and mites. New insecticides produced by industry are tested against the various insects and mites of interest to the Laboratory, so that up-to-date knowledge is obtained on the best chemicals to use against particular pests. Special groups deal with (1) fundamental studies on the mode of action of insecticides, including work on synergists, (2) the development of practical control measures for various stored product and domestic insects, including investigations in flour mills, studies on insecticidal lacquers, tests of various types of apparatus for applying insecticides, etc., (3) chemical studies, such as identification of the breakdown products of malathion in foodstuffs, determination of insecticidal residues, etc., and (4) mites.

Fumigants. The Fumigant Department investigates the behaviour of fumigants by chemical and physical methods, both in laboratory-scale and full-scale fumigation trials, using gas-concentration measurement as the basis. The work involves determining sorption of the fumigant by the commodity, the nature and extent of any reaction between it and the commodity, and the amount and nature of any chemical residue remaining after treatment, as well as effects on the nutritive or processing value of the commodity. Dosage-mortality data are obtained for various insects treated with different fumigants with a view to determining the fumigants

most suited to control particular types of infestation in particular circumstances. Studies are also made of the best ways of applying fumigants in practice and on the rate of build-up of insect populations from very small numbers such as might be represented by the survivors of a fumigation.

Biochemistry. The Biochemistry Department under Mr. F. P. W. Winteringham is concerned with biochemical and physiological problems of insecticidal action. Although the work is of a long-term and fundamental nature, two practical objectives are kept in mind: (1) the development of effective countermeasures against insects which have become resistant to the well known insecticides, and (2) the development of selective insecticides on a rational basis. The work of the department is of general interest to all branches of applied entomology—agricultural, stored product, veterinary and medical. Indeed the World Health Organisation is providing financial support for the work on dieldrin resistance.

Because of the small size of most insects, existing methods may have to be modified and new ones developed in order to study the action of insecticides on particular parts of insects. For example, methods are now under investigation for studying the biochemical changes which occur when the nerve cord of living cockroaches is stimulated. Radioactive isotopes, too, are extensively used to "label" insecticides and to study biochemical reactions both in the living insect and in isolated tissues. Where the labelled metabolites can be separated chromatographically they can be detected and estimated by scanning the chromatograms with a Geiger counter, and a number of instruments have been developed for this purpose. Such techniques have in the past been used to study the breakdown of DDT in resistant houseflies, and are now being used in a similar study of dieldrin resistance. Already a number of possible explanations have been eliminated. For example, work with a strain of houseflies resistant to dieldrin strongly suggests that the resistance mechanism does not involve (1) impermeability of the cuticle, (2) breakdown of the dieldrin by enzymes, (3) enhanced excretion of the dieldrin, or (4) storage of the dieldrin in an inert form. Instead, resistance appears to be due to some fundamental insensitivity at the normal site of action of the insecticide.

Selective toxicity is a somewhat different problem, in that the aim is to find insecticides which will be very poisonous to the pest one wishes to kill and much less poisonous either to the host organism or to beneficial insects. Biochemical differences between the organisms concerned could form a rational basis for the development of such selective insecticides. The task confronting the research worker is an immense one, but there are indications that such an approach is justified. For example, there are some biochemical mechanisms known to be unique to insects and, moreover, the toxic action of some naturally occurring substances is known to be highly selective. Considerations such as these indicate that the development of selective insecticides may be more than a theoretical possibility.

It is encouraging to know that the work of the Laboratory in the field of insect biochemistry is highly regarded, not only in this country, but in many countries abroad.

Tropical Liaison. The Tropical Liaison group (financed formerly by the Colonial Office and now by the Department of Technical Co-operation), deals with a considerable number of enquiries from overseas territories, keeps abreast of post-harvest problems in the British Colonies and Commonwealth, and is engaged in promoting improvements in the handling and storage of produce in these countries. Extensive tours have been made abroad by the senior officers of the group, who have been able to bring to the territories they have visited a fund of knowledge about pest infestation and its control, derived from the Laboratory to which the group is attached. On the other hand, conditions in tropical countries, especially, are very different from those in Britain and some of the problems met with need experimental investigation, both in the country where they occur and sometimes, in order to speed the results, in controlled environment conditions here, where facilities for such work are so much better developed.

FARM BUILDINGS RESEARCH

The Council has maintained that, in order to appreciate the direction and form that profitable farm buildings research should take in future, it is essential to have reliable information about farm buildings that exist already, and about research that has already been done. In the year under review the Council's survey of farm buildings has continued; and the remaining sections have been issued of a bibliography of farm buildings research publications that appeared between 1st January, 1945, and 30th April, 1958, in countries where conditions are relevant to those in Great Britain. The parts of this bibliography that have now been published relate to buildings for pigs, potato storage, poultry, cattle, grain drying and storage, fodder storage, and to miscellaneous items. Supplements will follow to keep this record up to date.

The Council's report for 1959-60 described the scheme under which the Council provides grants towards the cost of experimental farm buildings. This scheme came into operation on 1st July, 1960, and an experimental programme was prepared for 1961 and 1962 based on the principal problems in farm buildings as revealed in the proposals submitted for grant. During the year ended 30th June, 1961, a total of 177 applications was received, of which 27 were accepted as suitable for grant, 52 remained under consideration, and the remainder had been withdrawn by the applicants or rejected because they could not be fitted into the experimental programme. The projects in hand fall into six groups; methods of economising straw and labour in cattle yards; comparison of laying houses with wire-mesh or slatted floors with deep-litter houses; methods of housing hill sheep; the bulk storage of fertilisers on the farm; structures and ancillary equipment used for the handling and feeding of bulk cattle foods; and pig housing problems. Because of the wide interest in slatted floors the first group has attracted most attention. About £30,000 will have been paid in first instalments of grants during the financial year 1961-62 in respect of building work worth nearly £100,000 in total.

MONITORING OF RADIOACTIVITY IN THE FOOD CHAIN

The Council's Radiobiological Laboratory has continued a comprehensive monitoring survey of milk and other foods, herbage and soil, to determine the extent of their contamination by the most important radioactive components of fallout. Research has also continued into the movement of radionuclides in the food chain; and senior members of the staff of the Laboratory have, as in previous years, taken a prominent part in conferences at home and abroad concerned with the monitoring and effects of radioactive fallout. The Radiobiological Laboratory's report for 1960: "Surveys of Radioactivity in Human Diet and Experimental Studies" showed that during 1960 levels of strontium 90 in the average diet of the population of the United Kingdom fell to about three-quarters of the level for 1959. A decrease was expected as there were no tests of megaton thermonuclear weapons during 1959 and 1960. The effects of fallout consequent upon the tests in the autumn of 1961 are being studied closely and will be reported in later publications.

Operators of nuclear installations in Great Britain have statutory responsibilities for the protection of the population from radiation hazards, and the Agricultural Departments and the Ministry of Housing and Local Government are responsible for prescribing limits relating to the discharge of radioactive materials from these installations. To assist the Agricultural Departments in the discharge of their statutory duties the Radiobiological Laboratory has undertaken the collection and analysis of samples of soil, herbage and root-mat from the neighbourhood of nuclear installations to determine their content of significant radionuclides.

VACATION CONSULTANT SCHEME

As a means of strengthening the links between the research institutes and the scientific departments of the Universities the Council has introduced a scheme similar to that operated by the Department of Scientific and Industrial Research under which members of University staffs in the United Kingdom may spend a part of their vacation at the agricultural research institutes as consultants on a fee basis. Under this arrangement, academic scientists may for a period assist with the work or advise on particular problems at the research institutes. Apart from the direct contribution made by the consultants, the arrangement enables the scientists in the agricultural research service to work with specialist visitors who bring fresh minds to their problems, and provides an opportunity for members of University staffs to see something of the research programmes of the institutes and the way in which they are carried out.

ADMINISTRATION AND FINANCE

1960-61

HONOURS AND AWARDS

Her Majesty the Queen conferred the following honours :

C.B.E. ... Dr. F. R. Tubbs, Director, East Malling Research Station.

O.B.E. ... Miss M. D. Glynnne }
M.B.E. ... Mr. W. C. Game } Rothamsted Experimental Station.

Professor K. Mather, F.R.S., Honorary Director of the Council's Unit of Biometrical Genetics, was appointed Vice-Principal of the University of Birmingham.

Professor R. L. Wain, F.R.S., Honorary Director of the Council's Plant Growth Substances and Systemic Fungicides Unit, received the Research Medal for 1960 of the Royal Agricultural Society of England.

Dr. K. L. Blaxter of the Hannah Dairy Research Institute was awarded the Thomas Baxter Prize for 1960.

Dr. G. Jones of the Rowett Research Institute was awarded the Sophie Fricke Royal Society Research Fellowship for the academic year 1960-61.

VISIT BY H.M. THE KING OF NEPAL

The National Institute for Research in Dairying was honoured by a visit from His Majesty King Mahendra Bir Bickram Shahdeva of Nepal on 29th October, 1960.

STAFF

At 31st March, 1961, there were 4,669 members of staff employed at the agricultural research institutes. Of this number 916 were in the Scientific Officer Class, 687 in the Experimental Officer Class and 937 in the Scientific Assistant Class. The remainder were mainly in the Executive, Clerical and Industrial Classes. The number of staff employed in the Council's Secretariat was 88.

APPOINTMENTS AND RETIREMENTS

Sir Alan Drury, F.R.S., Head of the Pathology Department at the A.R.C. Institute of Animal Physiology, retired on 15th September, 1960, and was succeeded by Dr. T. Gillman. Other appointments at the Institute included that of Dr. M. Vogt, F.R.S., on 1st April, 1960, as Head of the Pharmacology Department and of Dr. R. D. Keynes, F.R.S., on 1st October, 1960, as Head of the Physiology Department.

Dr. H. Harris was appointed Head of the Cell Biology Department of the John Innes Institute on 1st June, 1960.

Mr. A. Oates was appointed as an Assistant Secretary to the Council in succession to Mr. P. A. C. Thorne, who retired from the Council's service on 30th June, 1960.

The following further changes in the Council's Headquarter's staff took place, following the period covered by this Report:—

Mr. J. Lamb, O.B.E., formerly Director of the West African Cocoa Research Institute, was appointed as Scientific Adviser to the Secretary of the Council on 1st May, 1961.

Dr. W. E. Berry was appointed as an Assistant Secretary to the Council in succession to Mr. W. Ness, C.B.E., who retired from the Council's service on 31st October, 1961.

OVERSEAS LIAISON

The considerable number of visitors welcomed at the various research centres included many hundreds of research workers and students from overseas. The visits ranged from short-term study tours, designed to acquaint visiting scientists with the work in progress at research institutes, to long periods of attachment in the case of foreign students under British Council and other auspices seeking further training in research methods and techniques. Technical co-operation with many of the international agencies, such as the Food and Agriculture Organisation of the United Nations, UNESCO, O.E.C.D., Colombo Plan and the International Atomic Energy Agency, was also furthered by the secondment of British research scientists to overseas territories.

The Council again provided funds to enable research workers in this country to make individual visits to research centres abroad and to participate in many of the international scientific conferences in various parts of the world. Included among the principal meetings in 1960 were the VIIth International Congress on Soil Science, Madison, Wisconsin, U.S.A., the Vth International Congress on Nutrition, Washington, D.C., and the XIth International Congress on Entomology, Vienna.

Two scientists from the agricultural research service visited the U.S.S.R. during the year under the agreement negotiated by the Soviet Relations Committee of the British Council with the U.S.S.R. State Committee for Cultural Relations with Foreign Countries.

The Secretary of the Council, as a member of the Colonial Committee for Agricultural, Animal Health and Forestry Research, visited East Africa to attend a meeting of the East African Agricultural and Fisheries Research Council in Nairobi.

BUILDINGS AND PROPERTY

A number of major schemes were completed during the year. These included additional laboratory accommodation for the Unit of Reproductive Physiology and Biochemistry; renovations and alterations to the Manor House at the National Institute for Research in Dairying; new laboratories at the Long Ashton Research Station; the resettlement of the Unit of Plant Morphogenesis and Nutrition; an extension to the laboratory at the Field Station, Compton, and a laboratory extension at the Scottish Horticultural Research Institute.

The major works in progress at the end of the year 1960-61 were:—

Animal Diseases Research Association, Moredun Institute: new microbiology laboratories.

Glasshouse Crops Research Institute: new heating system for trial glasshouses.

Houghton Poultry Research Station: facilities for research on diseases of the leucosis complex.

Institute of Animal Physiology: pig research laboratory.

Macaulay Institute for Soil Research: new laboratory accommodation.

National Institute of Agricultural Engineering, Scottish Station: general development of new site at the Bush Estate of the Edinburgh Centre of Rural Economy.

National Institute for Research in Dairying: radiobiochemistry building.

Radiobiological Laboratory: new laboratories.

Rothamsted Experimental Station: additional building for the Statistics Department.

Weed Research Organisation: general development of Begbroke Hill Farm, Oxford, including laboratories, farm buildings, etc.

The following projects were in various stages of planning:—

Animal Breeding Research Organisation: new headquarters building.

Animal Diseases Research Association, Moredun Institute: sheep metabolism and isotope unit.

Glasshouse Crops Research Institute: a laboratory/glasshouse unit for virus, entomological and nematological work.

Low Temperature Research Station: temporary facilities for meat storage and research.

National Institute of Agricultural Engineering: new building to house Field Investigation Department.

National Institute for Research in Dairying: new laboratory buildings (second wing), cowshed and milking parlour, small animal house, "germ free" research facilities and facilities for research on pig metabolism and baby pigs.

Pest Infestation Laboratory: new laboratory block and canteen.

Rothamsted Experimental Station: extension to the West Building.

Rowett Research Institute: new special services building and additional accommodation at experimental piggeries.

Welsh Plant Breeding Station: new laboratory building for developmental genetics.

LAND AGENCY SERVICE

The Council's Land Agents, Messrs. W. H. Cooke and Arkwright, have continued to give valuable assistance to the grant-aided institutes in England and Wales and to the Council's own establishments in planning

estate maintenance programmes and dealing with the many and varied problems of land and estate management that arise.

AGRICULTURAL RESEARCH FUND

The greater part of the Council's expenditure is met from the Agricultural Research Fund which is financed by a Parliamentary grant-in-aid. In the financial year ended 31st March, 1961, gross current expenditure was £5,327,685; capital expenditure on buildings and special apparatus amounted to £531,815. A grant-in-aid of £5,605,000 was voted by Parliament, of which £5,530,000 was drawn. The grant-in-aid was augmented by receipts totalling £265,764 derived from sales of livestock, produce, etc., at research institutes and units, from rents and hostel charges, and from the sale of publications and reports, as well as by contributions totalling £64,493 from Government Departments and other sources. These contributions included, *inter alia*, £17,634 from the Hops Marketing Board and the Institute of Brewing towards the cost of research on hops at Wye College; £10,000 from the Animal Health Trust towards the maintenance of the Houghton Poultry Research Station; £16,531 from the Colonial Office towards the cost of the Council's Unit of Experimental Agronomy and the maintenance of the Tropical Liaison Department of the Pest Infestation Laboratory; £13,817 from the United States Department of Agriculture under U.S. Public Law 480 in respect of agricultural utilisation research projects at the Low Temperature Research Station and the Ditton Laboratory; and £4,286 from the World Health Organisation towards the work of the Pest Infestation Laboratory.

The allocation under main heads of the total expenditure from the Agricultural Research Fund was as follows:—

	£	Percentage of total
Administration	171,788	2.9
Research institutes and units of the Council:		
Current expenditure	1,786,942	30.5
Capital expenditure	216,263	3.7
Special research grants	142,555	2.4
Studentships, training awards and fellowships (including travelling fellowships and grants for visits overseas)	45,072	0.8
Grants to independent research institutes (England and Wales):		
for current expenditure	3,181,328	54.3
for capital expenditure	315,552	5.4
	<u>£5,859,500</u>	<u>100.0</u>

GRANTS MADE FROM THE VOTE OF THE DEPARTMENT OF AGRICULTURE AND FISHERIES FOR SCOTLAND

Grants to the independent agricultural research institutes in Scotland are made from the Vote of the Department of Agriculture and Fisheries for Scotland, on the advice of the Council. For the financial year which ended on 31st March, 1961, the total of such grants was £984,976 for current expenditure and £253,382 for capital expenditure.

BENEFACTIONS

By the terms of its Charter, the Council is empowered to accept and administer private funds or properties which may be given or bequeathed to it in trust, either for the general purpose of its work or for special objects within its field.

(a) *The Underwood Fund*

This fund, of which the income during 1960-61 was £5,090, has continued to be used by the Council to provide Fellowships or grants for distinguished overseas scientists who wish to visit this country and who are likely, directly or indirectly, to assist the Council's work. The Council is willing to consider applications for Fellowships by, or on behalf of, such scientists, at any time of the year.

Recipients of grants made from the fund during 1960-61 included the following: Professor C. W. Emmens, of the Department of Veterinary Physiology, University of Sydney, who spent a year at the Royal Veterinary College; Dr. J. O. Corliss, Secretary of the American Society of Protozoologists, who visited a number of centres in the United Kingdom at which protozoological work is in progress; Dr. M. C. Chang, of the Worcester Foundation for Experimental Biology, Shrewsbury, Mass., who spent a year at the Council's Unit of Reproductive Physiology and Biochemistry; Professor F. W. Hill, Professor of Poultry Nutrition, Davis, California, who attended a symposium at the School of Agriculture, University of Nottingham; and Professors Fulton, Hewitt, Sill and Hidaka, who attended the Symposium on Soil-borne Viruses at the Scottish Horticultural Research Institute.

(b) *The Wain Fund*

The objects of this fund, which was established in 1958, are to facilitate the interchange of scientists between universities in the United Kingdom and overseas; to provide equipment in the universities in the United Kingdom for agricultural research; and to further other schemes of benefit to agricultural research for which the ordinary funds of the Council are not available.

No payments were made from the fund during the financial year 1960-61.

FINANCIAL ASSISTANCE FROM OUTSIDE BODIES

The Council gratefully acknowledges the assistance received during the year from the following:—

(1) *W. K. Kellogg Foundation*

The Foundation again offered four Fellowships to enable workers in the agricultural research service to spend study-periods of up to six months in the United States of America.

(2) *Hatley Foundation*

The Foundation have offered annual grants of \$3,400 for each of the calendar years 1958-60, to enable scientists to visit research institutes while in the United States; four scientists were assisted in this way during 1960-61.

(3) *Wellcome Trust*

The Trust made a grant of up to £15,250 to the Institute of Animal Physiology for the purchase of a Siemens electron microscope and ancillaries, and one of £1,350 to the Virus Research Unit for the purchase of a Swedish ultramicrotome.

(4) *Milk Marketing Board*

The Board made a grant of £2,500 p.a. for three years to the National Institute for Research in Dairying for research in connection with the bulk collection of milk.

(5) *National Institutes of Health of America*

A grant of \$73,242 was made by the National Institutes of Health to the Virus Research Unit for research on virus and nucleic acid structure during the year beginning 1st May, 1960.

(6) *United States Department of Agriculture*

The Department made the following research grants under United States Public Law 480 from counterpart funds available in the United Kingdom:—

To the Low Temperature Research Station: a grant of £35,900 for five years from July, 1960, for research on the causes and control of discoloration in processed potato products.

To the Ditton Laboratory: a grant of £23,865 for five years from September, 1960, for research on the effects of temperature, concentration of oxygen and of carbon dioxide on the respiratory gaseous exchange of apples.

To the Council's Field Station, Compton: a grant of £53,240 for five years from March, 1961, for an investigation of scrapie in sheep.

To the Animal Diseases Research Association, Moredun Institute: a grant of £53,700 for five years from 1961 for an extension of the Institute's programme of research into scrapie.

(7) *Dr. W. E. Ripper*

A second grant of £700 was made by Dr. Ripper, of Dow Agrochemicals Ltd., for the employment of a research assistant to further the work on herbicides which is being undertaken by the Council's Unit of Experimental Agronomy.

NORTHUMBERLAND,

Chairman of the Agricultural Research Council.

E. G. COX,

Secretary of the Council.

Cunard Building,
15, Regent Street,
London, S.W.1.

5th February, 1962.

APPENDIX I

COMMITTEES

(As at 31st March, 1961)

STANDING COMMITTEE ON RESEARCH AFFECTING ANIMALS

Professor P. B. Medawar, C.B.E., M.A., D.SC., F.L.S., F.R.S. (Chairman).
J. D. Alston, J.P.
H. R. Barnell, M.A., B.SC., PH.D.
Professor F. W. Rogers Brambell, B.A., D.SC., PH.D., F.R.S.
R. E. Glover, M.A., D.SC., F.R.C.V.S.
G. N. Gould, J.P., F.R.C.V.S.
F. H. K. Green, C.B.E., M.D., F.R.C.P.
Professor C. S. G. Grunsell, PH.D., M.R.C.V.S.
Professor J. W. Howie, M.D., M.R.C.P., F.R.F.P.S.
Elwyn Jones, O.B.E., J.P.
Professor Sir Hans A. Krebs, M.A., M.D., D.SC., F.R.C.P., F.R.S.
Professor P. L. Krohn, B.A., B.M., B.CH.
T. R. R. Mann, M.D., SC.D., PH.D., F.R.S.
Professor K. Mather, C.B.E., D.SC., PH.D., F.R.S.
Professor C. L. Oakley, M.D., B.S., D.SC., F.R.S.
Sir John Ritchie, C.B., B.SC., D.V.SC., F.R.C.V.S., D.V.S.M., F.R.S.E.
Professor C. H. Waddington, C.B.E., M.A., SC.D., D.ÈS.SC., F.R.S.
Professor W. L. Weipers, B.SC., F.R.C.V.S., D.V.S.M., F.R.S.E.
Professor E. G. White, D.SC., F.R.C.V.S.
Professor V. B. Wigglesworth, C.B.E., M.A., M.D., B.CHIR., F.R.S.

STANDING COMMITTEE ON RESEARCH AFFECTING PLANTS AND SOILS

Professor S. J. Watson, C.B.E., D.SC., F.R.I.C., F.R.S.E. (Chairman).
Professor R. M. Barrer, SC.D., F.R.S.
Professor T. A. Bennet-Clark, M.A., PH.D., F.R.S.
David Lowe, C.B.E., F.R.S.E.
Professor K. Mather, C.B.E., D.SC., PH.D., F.R.S.
W. C. Moore, C.B.E., M.A.
Professor G. Pontecorvo, DR. AGRIC., PH.D., F.R.S.
F. Rayns, C.B.E., M.A., SC.D.
Professor Alexander Robertson, M.A., B.SC., PH.D., LL.D., F.R.S.
H. G. Sanders, M.A., PH.D.
Professor P. T. Thomas, B.SC., PH.D.
Professor R. L. Wain, D.SC., PH.D., F.R.I.C., F.R.S.
Professor C. W. Wardlaw, D.SC., PH.D., F.R.S.E.
Professor V. B. Wigglesworth, C.B.E., M.A., M.D., B.CHIR., F.R.S.
Professor W. T. Williams, D.SC., PH.D.
F. Yates, SC.D., F.R.S.

SOIL SURVEY RESEARCH BOARD

- Sir William G. Ogg, M.A., B.SC., PH.D., LL.D., F.R.S.E. (Chairman).
Professor R. M. Barrer, SC.D., F.R.S.
J. Macdonald, C.B.E., B.SC.(FOR.), F.R.S.E.
W. Morley Davies, M.A., B.SC., F.R.I.C.
G. H. Mitchell, D.SC., F.R.S., F.R.S.E.
J. B. E. Patterson, M.SC., F.R.I.C.
N. H. Pizer, M.SC., PH.D., F.R.I.C.
D. Rhind, O.B.E., B.SC., F.L.S.
A. M. Smith, D.SC., PH.D.
Professor L. Dudley Stamp, C.B.E., B.A., D.SC., D.LIT., LL.D.
A. B. Stewart, M.A., B.SC., PH.D., F.R.I.C., F.R.S.E.
C. J. Stubblefield, D.SC., F.R.S.
Professor T. Wallace, C.B.E., M.C., D.SC., F.R.I.C., V.M.H., F.R.S.
A. S. Watt, B.A., PH.D., F.R.S.
A. Woodburn.
*A. Muir, B.SC., PH.D. (Technical Secretary).

* *Died 1st February, 1962.*

VETERINARY THERAPEUTIC TESTING BOARD

- Professor Alexander Robertson, M.A., B.SC., PH.D., LL.D., F.R.S. (Chairman of Board and Consultative Committee).
N. T. J. Bailey, M.A., D.SC.
N. M. Black, M.R.C.V.S.
*Professor G. Brownlee, D.SC., PH.D., F.P.S.
*J. W. Bruford, M.R.C.V.S.
*K. R. Capper, PH.D., B.PHARM., F.P.S., D.J.C.
W. S. Gordon, C.B.E., PH.D., M.R.C.V.S., F.R.S.E.
*F. H. K. Green, C.B.E., M.D., F.R.C.P.
*R. Paisley.
*R. Scarisbrick, M.A., PH.D., M.R.C.V.S., A.R.I.C.
J. B. White, M.R.C.V.S.
E. Wilkinson, M.R.C.V.S.
*W. R. Wooldridge, M.SC., PH.D., F.R.C.V.S., F.R.I.C.

* Also a member of the Board's Consultative Committee.

FARM BUILDINGS RESEARCH COMMITTEE

- Sir Walter Drummond, D.SC., M.INST.C.E., M.I.MECH.E. (Chairman).
W. H. Cashmore, C.B.E., B.A., N.D.A.
S. W. Cheveley, O.B.E.
Professor M. McG. Cooper, B.AGR.SC., B.LITT.
D. Duncan, A.A.DIP., A.R.I.B.A.
D. Grant, F.R.I.C.S.
W. O. Kinghorn, B.SC.
Miss I. O. H. Lepper
R. G. A. Lofthouse, F.L.A.S., F.R.J.C.S.
P. J. Macfarlan, B.SC., N.D.A., N.D.D.
G. D. Nash, A.R.I.B.A.
H. J. Rathbone, O.B.E., F.L.A.S.
F. G. Sturrock, M.A., B.SC., N.D.A., N.D.D.
J. K. W. Slater, M.A., M.SC. (Member and Technical Secretary).

FARMING ACTIVITIES OF RESEARCH INSTITUTES

J. D. Alston, J.P. (Chairman).
R. E. Glover, M.A., D.SC., F.R.C.V.S.
Elwyn Jones, O.B.E., J.P.
David Lowe, C.B.E., F.R.S.E.
F. Rayns, C.B.E., M.A., SC.D.
H. G. Sanders, M.A., PH.D.
F. Yates, SC.D., F.R.S.

FOOD RESEARCH COMMITTEE

David Lowe, C.B.E., F.R.S.E. (Chairman).
H. R. Barnell, M.A., M.SC., PH.D.
Professor T. A. Bennet-Clark, M.A., PH.D., F.R.S.
T. R. R. Mann, M.D., SC.D., PH.D., F.R.S.
Professor P. B. Medawar, C.B.E., M.A., D.SC., F.L.S., F.R.S.

TECHNICAL COMMITTEES

ANIMALS

FOOT-AND-MOUTH DISEASE

(Governing Body of Foot-and-Mouth Disease Research
Institute, Pirbright, Surrey)

S. W. Cheveley, O.B.E. (Chairman).
Professor A. W. Downie, M.D., D.SC., F.R.S.
Professor H. G. Lamont, O.B.E., D.SC., M.R.C.V.S.
Professor H. B. Maitland, M.D., M.SC.
Sir Richard Manktelow, K.B.E., C.B.
Sir John Ritchie, C.B., B.SC., F.R.C.V.S., D.V.S.M., F.R.S.E.
Professor Alex Robertson, M.A., B.SC., PH.D., M.R.C.V.S., F.R.I.C., F.R.S.E.
F. Kingsley Sanders, D.PHIL.

NUTRIENT REQUIREMENTS OF FARM LIVESTOCK

D. P. Cuthbertson, C.B.E., M.D., D.SC., LL.D., F.R.S.E. (Chairman).
Professor R. G. Baskett, O.B.E., M.SC., F.R.I.C.
A. W. Boyne, B.SC.
R. Braude, D.SC., PH.D.
A. Eden, M.A., PH.D., F.R.I.C., DIP.AGRIC.
S. K. Kon, D.SC., PH.D., F.R.I.C.
F. H. Moulton, M.SC.
Professor Alex Robertson, M.A., B.SC., PH.D., M.R.C.V.S., F.R.I.C., F.R.S.E.
J. A. B. Smith, C.B.E., D.SC., PH.D., F.R.S.E.
D. B. Wallace, M.A.
I. A. McK. Lucas, M.SC. (Technical Secretary).

PIG RESEARCH

Professor L. P. Pugh, M.A., B.SC., F.R.C.V.S. (Chairman).
Professor R. G. Baskett, O.B.E., M.SC., F.R.I.C.
H. R. Davidson, M.A., DIP.AGRIC.
H. P. Donald, D.SC., PH.D., F.R.S.E.
A. Eden, M.A., PH.D., F.R.I.C., DIP.AGRIC.
H. I. Field, M.SC., M.R.C.V.S.
E. G. Johnson.
Professor H. G. Lamont, O.B.E., D.SC., M.R.C.V.S.
P. J. Macfarlan, B.SC., N.D.A., N.D.D.
Sir John Ritchie, C.B., B.SC., D.V.SC., F.R.C.V.S., D.V.S.M., F.R.S.E.
Professor Alex Robertson, M.A., B.SC., PH.D., M.R.C.V.S., F.R.I.C., F.R.S.E.
R. Braude, D.SC., PH.D. (Member and Technical Secretary).

POULTRY RESEARCH

Professor K. Mather, C.B.E., D.SC., PH.D., F.R.S. (Chairman).
R. Coles, B.A., D.SC., PH.D.
H. R. Finn.
S. K. Kon, D.SC., PH.D., F.R.I.C.
Sir John Ritchie, C.B., B.SC., D.V.SC., F.R.C.V.S., D.V.S.M., F.R.S.E.
Alan Robertson, B.A., D.SC.
J. Sutton, M.B.E.
R. F. Gordon, D.SC., M.R.C.V.S. (Member and Technical Secretary).

SCRAPIE RESEARCH

R. E. Glover, M.A., D.SC., F.R.C.V.S. (Chairman).
E. A. Carmichael, C.B.E., M.D., F.R.C.P.
W. S. Gordon, C.B.E., PH.D., M.R.C.V.S., F.R.S.E.
E. Weston Hurst, M.D., D.SC., F.R.C.P.
R. Markham, M.A., PH.D., F.R.S.
Professor L. P. Pugh, M.A., B.SC., F.R.C.V.S.
Sir John Ritchie, C.B., B.SC., D.V.SC., F.R.C.V.S., D.V.S.M., F.R.S.E.
E. T. C. Spooner, M.A., M.D.
Professor Lord Stamp, M.A., M.B., B.CHIR.
J. T. Stamp, D.SC., M.R.C.V.S., F.R.S.E.

DISEASES OF SHEEP AND CATTLE

Sir John Ritchie, C.B., B.SC., D.V.SC., F.R.C.V.S., D.V.S.M., F.R.S.E. (Chairman).
R. E. Glover, M.A., D.SC., F.R.C.V.S.
W. S. Gordon, C.B.E., PH.D., M.R.C.V.S., F.R.S.E.
L. E. Hughes, M.R.C.V.S., D.V.S.M., N.D.A.
Professor J. E. Nichols, M.SC., PH.D., F.R.S.E.
Professor Alex Robertson, M.A., B.SC., PH.D., M.R.C.V.S., F.R.I.C., F.R.S.E.
A. W. Stableforth, D.SC., M.R.C.V.S., D.V.S.M.
J. T. Stamp, D.SC., M.R.C.V.S., F.R.S.E.
Professor W. L. Weipers, B.SC., F.R.C.V.S., D.V.S.M., F.R.S.E.
J. M. Payne, B.SC., PH.D., M.R.C.V.S. (Technical Secretary).

PLANTS AND SOILS

ENVIRONMENT IN GLASSHOUSES

Professor J. W. Munro, C.B.E., M.A., D.SC. (Chairman).
Professor G. E. Blackman, M.A., F.R.S.
W. H. Cashmore, C.B.E., B.A., N.D.A.
E. Danter, M.A., A.INST.P.
*Professor F. G. Gregory, D.SC., A.R.C.S., D.I.C., F.R.S.
Professor J. P. Hudson, M.B.E., G.M., M.SC., PH.D., N.D.H.
W. J. C. Lawrence, O.B.E., V.M.H.
E. R. Leonard, D.SC., A.R.C.S.
L. G. Morris, B.SC.(ENG.), A.F.R.A.E.S.
G. F. Sheard, M.SC.
L. P. Smith, B.A.
L. Stenning.
Principal M. A. H. Tincker, M.A., D.SC., F.L.S.
R. G. Voysey, A.C.G.I., A.M.I.MECH.E.
Professor C. P. Whittingham, B.A., PH.D.

* *Died 27th November, 1961.*

FIELD WATER CONTROL

A. B. Stewart, M.A., B.SC., PH.D., F.R.I.C., F.R.S.E. (Chairman).
Professor T. A. Bennet-Clark, M.A., PH.D., F.R.S.
W. H. Cashmore, C.B.E., B.A., N.D.A.
E. C. Childs, SC.D., PH.D.
Miss V. M. Conway, B.A., PH.D.
R. Glentworth, B.S.A., PH.D.
Sir Claude Inglis, C.I.E., M.A.I., M.I.C.E., F.R.S.
E. A. G. Johnson, C.B.E., B.SC., M.I.C.E., M.I.W.E.
W. O. Kinghorn, B.SC.
H. G. Lambert, M.A.
*A. Muir, B.SC., PH.D.
H. H. Nicholson, M.B.E., M.A.
H. L. Penman, M.SC., PH.D., F.INST.P.
F. J. Richards, D.SC., F.R.S.
R. H. Smith, B.A.
D. J. Watson, M.A., PH.D.
Rice Williams, O.B.E., D.SC.

* *Died 1st February, 1962.*

HOP RESEARCH

Professor T. Wallace, C.B.E., M.C., D.SC., F.R.I.C., V.M.H., F.R.S. (Chairman).
G. D. H. Bell, B.SC., PH.D.
A. H. Cook, D.SC., F.R.I.C., F.R.S.
A. Cronk.
H. S. Darling, B.SC., PH.D., M.AGR., A.I.C.T.A.
H. J. Hamblin, O.B.E., B.A.
R. V. Harris, D.SC., A.R.C.S., D.I.C.
W. G. Keyworth, PH.D., A.R.C.S., D.I.C.
W. C. Moore, C.B.E., M.A.
Sir Thomas Neame.
J. Nott, M.B.E.
N. B. Smiley.
Professor R. L. Wain, D.SC., PH.D., F.R.I.C., F.R.S.

POTATO PROBLEMS

Sir William G. Ogg, M.A., B.SC., PH.D., LL.D., F.R.S.E. (Chairman).
G. D. H. Bell, B.SC., PH.D.
W. Black, D.SC., PH.D., F.R.S.E.
W. G. Burton, B.SC., M.A.
K. S. Dodds, D.SC., PH.D.
J. L. Hardie, B.SC., PH.D.
J. M. Hirst, D.SC., PH.D.
F. R. Horne, C.B.E., M.A., N.D.A., N.D.D.
E. C. Large, B.SC., F.R.I.C.
David Lowe, C.B.E., F.R.S.E.
Mrs. N. McDermott, M.B.E., M.SC.
J. Marshall.
Professor F. L. Milthorpe, M.SC., PH.D., D.I.C.
Professor Alexander Robertson, M.A., B.SC., PH.D., LL.D., F.R.S.
F. E. Shotton, M.A., DIP.AGRIC.
A. R. Wilson, B.SC., M.S., PH.D.

SPRAY DRIFT

Professor H. G. H. Kearns, O.B.E., B.SC., PH.D., DIP.AGRIC. (Chairman).
W. H. Cashmore, C.B.E., B.A., N.D.A.
R. F. Hill.
W. C. Moore, C.B.E., M.A.
James Philp, B.SC., PH.D., F.L.S.
B. D. A. Tucker.
Professor R. L. Wain, D.SC., PH.D., F.R.I.C., F.R.S.
E. K. Woodford, O.B.E., M.SC., PH.D., D.I.C.

GROUPS ANIMALS CARCASE QUALITY STUDIES

R. Scarisbrick, M.A., PH.D., M.R.C.V.S., A.R.I.C. (Chairman).
 A. J. Brookes, M.A.
 D. P. Gatherum.
 F. R. Gerrard, M.B.E.
 G. Harrington, M.A.
 Sir John Hammond, C.B.E., M.A., D.SC., F.R.S.
 K. Bryce Jones, B.SC., PH.D., F.R.I.C., A.R.C.S.
 J. W. B. King, M.A., PH.D.
 G. E. Lamming, B.SC., M.S., PH.D.
 R. A. Lawrie, PH.D., A.R.I.C.
 P. J. Macfarlan, B.SC., N.D.A., N.D.D.
 I. L. Mason, B.A.
 R. W. Pomeroy, M.A., PH.D.
 T. R. Preston, B.SC., PH.D.
 J. C. Tayler, M.A., DIP.AGRIC.

COLLABORATIVE TESTS OF PROTEIN QUALITY IN ANIMAL FEEDING STUFFS

S. K. Kon, D.SC., PH.D., F.R.I.C. (Chairman).
 *A. E. Bender, B.SC., PH.D., F.R.I.C.
 A. A. Bindloss, B.SC., DIP.AGRIC.
 *A. W. Boyne, B.SC.
 R. Braude, D.SC., PH.D.
 *K. J. Carpenter, M.A., B.SC., PH.D.
 Marie E. Coates, PH.D., F.P.S.
 *W. F. J. Cuthbertson, B.SC., PH.D., F.R.I.C.
 Kathleen M. Henry, D.SC, PH.D., A.R.C.S.C.I., F.R.I.C.
 A. E. Humphreys.
 D. B. Lisle, B.SC., PH.D., A.R.I.C.
 D. S. Miller, B.SC.
 †F. H. Moul, M.SC.
 *W. R. Muir, B.SC.
 June N. Olley, PH.D.
 S. A. Price, B.SC., F.R.I.C.
 G. D. Rosen, B.SC., PH.D., F.R.I.C.
 G. Walley, B.SC., F.R.I.C.
 A. L. Walther, M.A., M.R.C.V.S.
 *A. A. Woodham, B.SC., PH.D.

* Also member of the Steering Committee.
 † Chairman of the Group's Steering Committee.

OESTROGENS

(Appointed in consultation with the M.R.C.)

Professor Sir Solly Zuckerman, C.B., M.A., M.D., D.SC., F.R.S. (Chairman).
 P. M. F. Bishop, D.M.
 W. E. Bowden.
 Professor Sir Charles Dodds, M.V.O., D.SC., PH.D., M.D., F.R.C.P., F.R.I.C., F.R.S.
 S. J. Folley, D.SC., PH.D., F.R.S.
 R. F. Glascock, B.SC., PH.D.
 G. E. Lamming, B.SC., M.S., PH.D.
 A. S. Parkes, C.B.E., M.A., SC.D., F.R.S.
 T. R. Preston, B.SC., PH.D.

PLANTS AND SOILS

COMPARISON OF METHODS OF ANALYSIS OF MINERAL ELEMENTS IN PLANTS

J. B. E. Patterson, M.Sc., F.R.I.C. (Chairman).
M. Allen, B.Sc.
C. Bould, M.Sc., Ph.D.
W. M. Crooke, B.Sc., Ph.D., A.R.I.C.
E. J. Hewitt, B.Sc., Ph.D., A.K.C.
E. C. Humphries, D.Sc.
R. L. Mitchell, B.Sc., Ph.D., F.R.I.C., F.R.S.E.
D. J. D. Nicholas, D.Sc., Ph.D., A.K.C., F.R.I.C.
F. H. Vanstone, B.Sc., Ph.D., A.Inst.P.
R. G. Warren, B.Sc.

A.R.C. SCHOLARSHIPS COMMITTEE

E. G. Cox, T.D., D.Sc., F.Inst.P., F.R.I.C., F.R.S. (Chairman of Main Committee).

BOTANY GROUP

Professor T. A. Bennet-Clark, M.A., Ph.D., F.R.S. (Chairman).
Professor P. H. Gregory, D.Sc., D.I.C.
Professor K. Mather, C.B.E., D.Sc., Ph.D., F.R.S.
Professor W. T. Williams, D.Sc., Ph.D.

CHEMISTRY GROUP

Professor Alexander Robertson, M.A., B.Sc., Ph.D., LL.D., F.R.S. (Chairman).
Professor R. A. Morton, D.Sc., Ph.D., F.R.I.C., F.R.S.
N. W. Pirie, M.A., F.R.S.
Professor R. L. Wain, D.Sc., Ph.D., F.R.I.C.

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W. H. Cashmore, C.B.E., B.A., N.D.A.
Professor E. M'Ewen, M.Sc., M.I.Mech.E.
Professor W. A. Tuplin, D.Sc., M.I.Mech.E.

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Professor V. B. Wigglesworth, C.B.E., M.A., M.D., B.Chir., F.R.S. (Chairman).
K. Mellanby, C.B.E., B.A., Sc.D., Ph.D.
I. Thomas, M.Sc., Ph.D.
D. W. Wright, M.A.

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D. J. Finney, M.A., Sc.D., F.R.S., F.R.S.E.
F. Yates, Sc.D., F.R.S.

ZOOLOGY GROUP

Professor C. F. A. Pantin, M.A., Sc.D., F.R.S. (Chairman).
J. B. Brooksby, D.Sc., Ph.D., M.R.C.V.S.
H. P. Donald, D.Sc., Ph.D., F.R.S.E.
Professor J. W. Howie, M.D., M.R.C.P., F.R.F.P.S.
Professor D. R. Newth, Ph.D.
A. W. Stableforth, D.Sc., M.R.C.V.S., D.V.S.M.

INTERDEPARTMENTAL AND JOINT COMMITTEES

JOINT A.I.C./A.R.C. COMMITTEE

A. B. Stewart, M.A., B.SC., PH.D., F.R.I.C., F.R.S.E. (Chairman).
J. F. Duncan, LL.D.
R. E. Glover, M.A., D.SC., F.R.C.V.S.
Professor Sir Joseph B. Hutchinson, C.M.G., SC.D., F.R.S.
F. Rayns, C.B.E., M.A., SC.D.
H. G. Sanders, M.A., PH.D.
A. R. Wannop, O.B.E., B.ENG., F.R.S.E.

JOINT A.R.C./M.R.C./D.C. COMMITTEE ON BIOLOGICAL PROBLEMS (NON-MEDICAL) OF NUCLEAR PHYSICS

Sir James Denby Roberts, Bart., O.B.E., J.P. (Chairman).
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Professor G. E. Briggs, M.A., F.R.S.
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A. S. McLean, M.B., CH.B., D.I.H., C.P.H.
W. G. Marley, O.B.E., M.SC., PH.D.
R. Scott Russell, M.A., M.SC., PH.D.
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A. W. Stableforth, D.SC., M.R.C.V.S., D.V.S.M.
E. B. Worthington, M.A., PH.D.

MANAGING SUB-COMMITTEE ON MONITORING

J. F. Loutit, C.B.E., D.M., F.R.C.P. (Chairman).
N. T. J. Bailey, M.A., D.SC.
K. L. Blaxter, D.SC., PH.D., N.D.A.
F. J. Bryant, B.SC., PH.D., D.I.C., A.R.C.S.
D. J. Finney, M.A., SC.D. F.R.S., F.R.S.E.
Miss D. F. Hollingsworth, O.B.E., B.SC.
J. L. McGirr, B.SC., M.R.C.V.S.
W. G. Marley, O.B.E., M.SC., PH.D.
Professor W. V. Mayneord, C.B.E., D.SC., F.I.P.
E. R. Mercer, B.SC.
R. Scott Russell, M.A., M.SC., PH.D.
C. L. Smith, PH.D.

APPENDIX II

SUMMARY OF THE EXPENDITURE OF THE COUNCIL DURING THE YEAR ENDED 31ST MARCH, 1961

	<i>Current</i>	<i>Capital</i>	<i>Receipts</i>	<i>Net Total</i>
	£	£	£	£
Headquarters: administration	171,788	—	6,744	165,044
Field Station, Compton	315,955	62,570	117,439	261,086
Animal Breeding Research Organisation	263,744	10,396	115,803	158,337
Institute of Animal Physiology	264,698	20,697	16,540	268,855
Poultry Research Centre	79,472	3,167	2,669	79,970
Unit of Insect Physiology	32,913	—	—	32,913
Virus Research Unit	37,662	1,311	—	38,973
Unit of Reproductive Physiology and Bio-chemistry	53,124	14,630	2,101	65,653
Unit of Experimental Agronomy	31,529	—	7,330	24,199
Unit of Animal Genetics	64,756	—	—	64,756
Unit of Systemic Fungicides	16,799	1,700	—	18,499
Unit of Statistics	12,828	—	—	12,828
Radiobiological Laboratory	61,146	46,590	115	107,621
Unit of Plant Physiology	21,450	—	—	21,450
Unit of Plant Morphogenesis and Nutrition	11,026	12,339	—	23,365
Weed Research Organisation	36,524	32,379	5,020	63,883
Farm Buildings Unit	8,494	3,516	139	11,871
Other Units	29,363	—	—	29,363
Dutton Laboratory	92,051	1,250	2,569	90,732
Low Temperature Research Station	163,297	—	11,969	151,328
Pest Infestation Laboratory	159,431	5,718	14,185	150,964
External Scientific Staff	30,680	—	—	30,680
Special Research Grants to Universities, etc.	142,555	—	—	142,555
Training Awards and Fellowships	27,135	—	—	27,135
Visits Abroad	17,937	—	—	17,937
Grants to Research Institutes:—				
Long Ashton Research Station	241,093	72,867	—	313,960
East Malling Research Station	315,106	1,191	—	316,297
Foot-and-Mouth Disease Research Institute	299,700	45,456	—	345,156
Glasshouse Crops Research Institute	120,242	21,680	—	141,922
Grassland Research Institute	174,990	5,136	—	180,126
Houghton Poultry Research Station	70,523	21,502	10,000	82,025
John Innes Institute	129,833	23,929	—	153,762
Hop Research Centre, Wye College	29,390	—	17,634	11,756
National Institute of Agricultural Engineering	420,687	5,561	—	426,248
National Vegetable Research Station	142,625	16,625	—	159,250
Plant Breeding Institute, Cambridge	88,406	4,725	—	93,131
National Institute for Research in Dairying	423,446	19,066	—	442,512
Rothamsted Experimental Station	577,388	57,009	—	634,397
Welsh Plant Breeding Station	147,899	14,887	—	162,786
Hannah Dairy Research Institute	—	5,918	—	5,918
TOTAL	5,327,685	531,815	330,257	5,529,243

**GRANTS MADE BY THE DEPARTMENT OF AGRICULTURE
AND FISHERIES FOR SCOTLAND TO RESEARCH
INSTITUTES IN SCOTLAND DURING THE YEAR
ENDED 31ST MARCH, 1961**

	<i>Current</i>	<i>Capital</i>	<i>Total</i>
	£	£	£
Animal Diseases Research Association	110,113	23,182	133,295
Rowett Research Institute	274,315	13,437	287,752
Hannah Dairy Research Institute	113,661	177	113,838
Scottish Society for Research in Plant Breeding ...	61,640	—	61,640
Macaulay Institute for Soil Research	202,895	127,019	329,914
National Institute of Agricultural Engineering (Scottish Station)	47,900	66,136	114,036
Scottish Horticultural Research Institute	103,020	10,478	113,498
Hill Farming Research Organisation	71,432	12,953	84,385
TOTAL	984,976	253,382	1,238,358

APPENDIX III

STATE-AIDED AGRICULTURAL RESEARCH INSTITUTES

England and Wales	<i>Tel. No.</i>
Agricultural and Horticultural Research Station, Long Ashton, Bristol. <i>Director:</i> Professor H. G. H. Kearns, O.B.E., B.Sc., Ph.D., DIP.AGRIC.	Long Ashton 2181
East Malling Research Station, Maidstone, Kent. <i>Director:</i> F. R. Tubbs, C.B.E., M.Sc., Ph.D., A.R.C.S., D.I.C., F.L.S.	West Malling 3033
Foot-and-Mouth Disease Research Institute, Research Institute (Animal Virus Diseases), Pirbright, Surrey. <i>Director:</i> Ian A. Galloway, D.Sc., M.R.C.V.S.	Worplesden 2441
Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex. <i>Director:</i> F. W. Toovey, O.B.E., B.Sc., A.R.C.S., A.I.C.T.A.	Littlehampton 1414
Grassland Research Institute, Hurley, Maidenhead, Berks. <i>Director:</i> William Davies, D.Sc.	Hurley 363/4
Houghton Poultry Research Station, Houghton, Huntingdon. <i>Director:</i> R. F. Gordon, D.Sc., M.R.C.V.S.	St. Ives (Hunts) 3168-9 and 3388
John Innes Institute, Bayfordbury, Hertford, Herts. <i>Director:</i> K. S. Dodds, D.Sc., Ph.D.	Hertford 3191
National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds. <i>Director:</i> W. H. Cashmore, C.B.E., B.A., N.D.A.	Silsoe 421
National Institute for Research in Dairying, Shinfield, Reading, Berks. <i>Director:</i> Professor R. G. Baskett, O.B.E., M.Sc., F.R.I.C.	Reading 83103
National Vegetable Research Station, Wellesbourne, Warwick. <i>Director:</i> James Philp, B.Sc., Ph.D., F.L.S.	Wellesbourne 382/4

Plant Breeding Institute, Maris Lane, Trumpington, Cambridge.	<i>Tel. No.</i>
<i>Director:</i> G. D. H. Bell, B.Sc., PH.D.	Trumpington 323 4
Rothamsted Experimental Station, Harpenden, Herts.	
<i>Director:</i> F. C. Bawden, M.A., F.R.S.	Harpenden 4671
Welsh Plant Breeding Station, Plas Gogerddan, Aberystwyth, Cardiganshire.	
<i>Director:</i> Professor P. T. Thomas, B.Sc., PH.D.	Bow Street 255/57
Wye College Hop Research Centre, Ashford, Kent.	
<i>Head of Department:</i> H. S. Darling, B.Sc., PH.D., M.AGRIC., A.I.C.T.A.	Wye 401

Scotland

Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh.	
<i>Director:</i> J. T. Stamp, D.Sc., M.R.C.V.S., F.R.S.E.	Liberton 3262
Hannah Dairy Research Institute, Kirkhill, Ayr.	
<i>Director:</i> J. A. B. Smith, C.B.E., D.Sc., PH.D., F.R.S.E.	Prestwick 77292/3
Hill Farming Research Organisation, 48, Palmerston Place, Edinburgh, 12.	
<i>Director:</i> A. R. Wannop, O.B.E., B.Sc.(AGR.), B.ENG., F.R.S.E.	Caledonian 3231/2
Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen.	
<i>Director:</i> A. B. Stewart, C.B.E., M.A., B.Sc., PH.D., F.R.I.C., F.R.S.E.	Aberdeen 38611
National Institute of Agricultural Engineering, Scottish Station, Bush and Dryden Estates, Milton Bridge, Penicuik, Midlothian.	
<i>Director:</i> W. J. West, B.A., DIP.AGRIC.	Fairmilehead 2147/8
Rowett Research Institute, Bucksburn, Aberdeen.	
<i>Director:</i> D. P. Cuthbertson, C.B.E., M.D., D.Sc., LL.D., F.R.S.E.	Bucksburn 8
Scottish Horticultural Research Institute, Mylnefield, Invergowrie, Dundee.	
<i>Director:</i> T. Swarbrick, M.Sc., PH.D.	Invergowrie 441

Scottish Plant Breeding Station,
Pentlandsfield,
Roslin,
Midlothian.

Tel. No.

Director: J. W. Gregor, C.B.E., D.SC., PH.D., F.L.S., F.R.S.E.

Fairmilehead 2171/2

AGRICULTURAL RESEARCH COUNCIL INSTITUTES AND UNITS

Field Station,
Compton,
Newbury,
Berks.

Tel. No.

Director: W. S. Gordon, C.B.E., PH.D., M.R.C.V.S., F.R.S.E.

Compton 343

Animal Breeding Research Organisation,
H.Q.: 6, South Oswald Road,
Edinburgh, 9.

Director: H. P. Donald, D.SC., PH.D., F.R.S.E.

Newington 3725

Institute of Animal Physiology,
Babraham,
Cambridge.

Director: J. H. Gaddum, M.A., SC.D., M.R.C.S., L.R.C.P., F.R.S.,
F.R.S.E.

Sawston 2312

Poultry Research Centre,
King's Building,
West Mains Road,
Edinburgh, 9.

Director: A. W. Greenwood, C.B.E., D.SC., PH.D., F.R.S.E.

Newington 4461

Ditton Laboratory,
Larkfield,
Maidstone,
Kent.

Director: R. G. Tomkins, M.A., PH.D., M.INST.R.

West Malling 3441

Low Temperature Research Station,
Downing Street,
Cambridge.

Director: E. C. Bate-Smith, SC.D., PH.D., M.INST.R., F.L.S.

Cambridge 50477

Pest Infestation Laboratory,
London Road,
Slough,
Bucks.

Director: G. V. B. Herford, C.B.E., M.SC.

Slough 21295

Radiobiological Laboratory,
Letcombe Regis,
Wantage,
Berks.

Director: R. Scott Russell, M.A., M.SC., PH.D.

Wantage 327

Weed Research Organisation,
Begbroke Hill,
Kidlington,
Oxford.

Director: E. K. Woodford, O.B.E., M.SC., PH.D., D.I.C.

Kidlington 3461

Farm Buildings Unit, Wrest Park Lodge, Silsoe, Beds.	<i>Tel. No.</i>
<i>Honorary Director:</i> W. H. Cashmore, C.B.E., B.A., N.D.A.	Silsoe 421
Unit of Animal Genetics, Institute of Animal Genetics, Edinburgh University, King's Buildings, West Mains Road, Edinburgh, 9.	
<i>Honorary Director:</i> Professor C. H. Waddington, C.B.E., M.A., SC.D., F.R.S.	Newington 1081
Unit of Biometrical Genetics, Department of Genetics, University of Birmingham, Edgbaston, Birmingham, 15.	
<i>Honorary Director:</i> Professor K. Mather, C.B.E., D.SC., PH.D., F.R.S.	Edgbaston 1552
Unit of Embryology, University College of North Wales, Bangor, Caerns.	
<i>Honorary Director:</i> Professor F. W. Rogers Brambell, B.A., D.SC., PH.D., F.R.S.	Bangor 3225
Unit of Experimental Agronomy, Department of Agriculture, University of Oxford.	
<i>Honorary Director:</i> Professor G. E. Blackman, M.A., F.R.S.	Oxford 57245
Unit of Insect Physiology, Department of Zoology, University of Cambridge, Downing Street, Cambridge.	
<i>Director:</i> Professor V. B. Wigglesworth, C.B.E., M.A., M.D., B.CHIR., F.R.S.	Cambridge 58717
Unit of Microbiology, Department of Microbiology, Sheffield University.	
<i>Honorary Director:</i> Professor S. R. Elsdon, B.A., PH.D.	Sheffield 27451
Unit of Plant Morphogenesis and Nutrition, Wye College, Ashford, Kent.	
<i>Director:</i> F. J. Richards, D.SC., F.R.S.	Wye 401
Unit of Plant Physiology, Imperial College of Science and Technology, Beit Building, Prince Consort Road, London, S.W.7.	
<i>Director:</i> Professor Helen K. Porter, D.SC., F.R.S.	Kensington 5111
Unit of Reproductive Physiology and Biochemistry, 307, Huntingdon Road, Cambridge.	
<i>Director:</i> T. R. R. Mann, M.D., SC.D., PH.D., F.R.S.	Cambridge 76278

Unit of Soil Physics, School of Agriculture, University of Cambridge, Huntingdon Road, Cambridge.	<i>Tel. No.</i>
<i>Director:</i> E. C. Childs, SC.D., PH.D.	Cambridge 76190
Unit of Statistics, University of Aberdeen, Meston Walk, Old Aberdeen.	
<i>Director:</i> D. J. Finney, M.A., SC.D., F.R.S., F.R.S.E.	Aberdeen 45251
Statistics Group, School of Agriculture, University of Cambridge.	
<i>Under Supervision of:</i> R. C. Campbell, M.A., PH.D.	Cambridge 58381
Systemic Fungicide Unit, Wye College, Ashford, Kent.	
<i>Honorary Director:</i> Professor R. L. Wain, D.SC., PH.D., F.R.I.C., F.R.S.	Wye 401
Virus Research Unit, Huntingdon Road, Cambridge.	
<i>Director:</i> R. Markham, M.A., PH.D., F.R.S.	Cambridge 76146 and 76620

APPENDIX IV

RESEARCH STUDENTSHIPS AND FELLOWSHIPS

(a) RESEARCH STUDENTSHIPS

These studentships are intended to enable young graduates who wish to make a career in agricultural research either to take a further course of study or to undertake a specific research project under supervision as a means of training in research methods, or to read for a veterinary degree in order to equip themselves for research in fields in which this added qualification is likely to be of particular advantage. They are open to honours graduates in science or those holding a veterinary qualification and to honours graduates in agriculture or horticulture who have shown special interest in one of the basic sciences.

The following twenty-one awards were made in 1960:—

<i>Name</i>	<i>Place of Tenure</i>	<i>Subject</i>
B. W. Bainbridge ...	Sheffield University ...	Plant Genetics
Miss E. G. Browne ...	Cambridge University ...	Veterinary Training Grant
P. E. Brumby ...	Nottingham University ...	Biochemistry
J. I. Davies ...	University College of North Wales ...	Biochemistry
A. Goldsworthy ...	University College, Swansea	Plant Biochemistry
C. J. Grant ...	Oxford University ...	Botany (Cytology)
Miss M. P. Jagoe ...	Birmingham University ...	Plant Physiology
T. L. McC. Kyle ...	Glasgow University ...	Veterinary Training Grant
D. H. Lewis ...	Oxford University ...	Plant Physiology
C. J. Mapes ...	Bristol University ...	Parasitology
P. J. Randall ...	Welsh Plant Breeding Station	Plant Breeding
D. H. Roberts...	London School of Hygiene and Tropical Medicine ...	Animal Pathology
J. D. Robson ...	Durham University ...	Pedology
J. Roseweir ...	University College of Wales...	Plant Genetics
D. Scott ...	Rowett Research Institute ...	Animal Biochemistry
D. G. Smith ...	Reading University ...	Microbiology
J. P. Spradbery ...	Rothamsted Experimental Station ...	Entomology
J. Stevenson ...	Liverpool University ...	Biochemistry
J. K. Syers ...	Durham University ...	Soil Chemistry
M. A. Venis ...	Oxford University ...	Agricultural Chemistry
Miss M. W. Walter ...	London University ...	Plant Biochemistry

At 31st March, 1961, the number of students in training was 55 divided amongst the different disciplines as follows:—

<i>Botany</i>	<i>Chemistry</i>	<i>Entomology</i>	<i>Zoology and Veterinary Science</i>
20	19	6	10

(b) FELLOWSHIPS

Up to three Agricultural Research Fellowships, tenable for a maximum period of three years, are available annually.

Veterinary Research Fellowships, tenable for three years, are available to veterinary graduates with not less than three years' post-graduate experience who wish to continue their researches for a further period before seeking a post.

No awards were made during the year under review.

APPENDIX V

SPECIAL RESEARCH GRANTS

During the period covered by this report the Council have continued to make grants to Universities, Colleges and other organisations, to assist in research projects on subjects of interest to the Council. Grants are normally limited to three years but occasionally they are made for longer periods.

The following is a list of projects supported by the Council as at 31st March, 1961:—

1. ABERDEEN UNIVERSITY

(i) *Department of Bacteriology*

Purchase of a fluorescence microscope for research in agricultural bacteriology.

(ii) *Department of Soil Science*

Research on the composition and properties of soil organic matter.

2. ABERYSTWYTH, UNIVERSITY COLLEGE OF WALES

(i) *Department of Agriculture*

The establishment and subsequent development of species sown by means of a sod seeder.

(ii) *Department of Agricultural Biochemistry*

(a) The susceptibility of certain strains of barley to D.D.T.

(b) The biosynthesis of thiamine in micro-organisms.

(iii) *Department of Agricultural Botany*

A comparative biochemical assessment of specific genotypes of herbage grasses in relation to their physiological characteristics.

(iv) *Department of Animal Husbandry*

The feed intake and requirements of sheep at different stages of production and at grazing.

3. BANGOR, UNIVERSITY COLLEGE OF NORTH WALES

(i) *Department of Agricultural Botany*

The mineral nutrition of contrasting natural populations of agriculturally-important grass species.

(ii) *Department of Agricultural Chemistry*

(a) The use of paper chromatography and similar methods for inorganic analysis in connection with soils, plants and animals.

(b) The biochemical and nutritive properties of pasture plants (A long-term grant).

(c) The metabolism of synthetic oestrogens and their derivatives by soil micro-organisms.

(d) Serological investigations.

(e) The metabolism of hill sheep in their natural environment.

(f) The influence of nutritional factors upon peptidase activity.

4. BIRMINGHAM UNIVERSITY

Department of Botany

A taxonomic investigation of the tuber-bearing species of *Solanum* using serological and other techniques.

5. BRISTOL UNIVERSITY

- (i) *Department of Animal Husbandry*
The nutrition of the baby pig.
- (ii) *Department of Pharmacology*
Research on the determination of oxytocin in blood.
- (iii) *Department of Physiology*
Research on bovine acetonaemia.

6. CAMBRIDGE UNIVERSITY

- (i) *School of Agriculture*
 - (a) Mycological aspects of cellulose decomposition in soils.
 - (b) The carcass quality of beef.
 - (c) Protein quality in human foods and animal feeding stuffs.
 - (d) Studies of poultry genetics employing inbred lines.
- (ii) *Department of Animal Pathology*
 - (a) Research on respiratory diseases in poultry.
 - (b) Research on virus diseases of pigs.
- (iii) *Department of Biochemistry*
 - (a) The biochemistry of chloroplasts in relation to photosynthetic phosphorylation.
 - (b) The organisation and chemical composition of plant cell walls during growth.
 - (c) The biochemical synthesis of plant cell wall constituents.
 - (d) The biochemistry of the uterus.
- (iv) *Department of Colloid Science*
The surface properties of cells.
- (v) *Physiological Laboratory*
Research on reflex control of the ruminant stomach.
- (vi) *School of Veterinary Medicine*
 - (a) The sow's mammary gland in health and disease.
 - (b) Research on piglet mortality with particular reference to transmissible gastro-enteritis. (A long-term grant).
 - (c) Research on immunity to helminth infection with special reference to functional antigens.
- (vii) *Department of Veterinary Clinical Studies*
 - (a) The physiological basis of neonatal mortality among animals. (A long-term grant).
 - (b) Blood groups of the pig.
 - (c) The biochemistry of blood copper and iron in the bovine.

7. DURHAM UNIVERSITY (KING'S COLLEGE, NEWCASTLE-UPON-TYNE)

School of Agriculture

- (a) The restoration of open-cast coal sites.
- (b) The biology and ecology of frit fly in Northumberland.
- (c) Studies of pig farrowing accommodation. (A long-term grant).
- (d) The progeny testing of cattle for meat and milk production.

8. EDINBURGH UNIVERSITY

- (i) *School of Agriculture*
Research on egg weight in the domestic fowl: the genetic determination of initial egg weight and its increase to mature weight.
- (ii) *Department of Biochemistry*
The metabolism of radioiron in immature pullet and laying hens.

- (iii) *Department of Zoology*
 - (a) Immature stages of *Trichostrongylus retortaeformis*.
 - (b) Research on insect cell culture.
- (iv) *Royal (Dick) School of Veterinary Studies*
Department of Veterinary Hygiene and Preventive Medicine
 Study of citrate metabolism in ruminants.

9. GLASGOW UNIVERSITY

- (i) *Department of Bacteriology*
 Research on aerobic spore-forming bacteria pathogenic for Lepidoptera.
- (ii) *Veterinary School*
 - (a) Electrolyte and body fluid changes in calf diarrhoea.
 - (b) A study of bovine brucellosis in the field.
 - (c) Bacteriological research.
 - (d) The urinary changes associated with electrolyte changes in body fluids.
 - (e) Research on the role of larval and adult stages in immunity to Haemonchiosis.

10. HARPER ADAMS AGRICULTURAL COLLEGE

- (a) Pig husbandry investigations.
- (b) Poultry husbandry investigations.

11. HOUGHTON POULTRY RESEARCH STATION

Avian physiology.

12. LEEDS UNIVERSITY

- (i) *Department of Agriculture*
 - (a) Research on clover rot.
 - (b) The nutrition of the pregnant sow.
- (ii) *Department of Biochemistry*
 The assay of glucagon-activity in tissues of man and other mammals.
- (iii) *Department of Biomolecular Structure*
 - (a) Interpretation of fibre types in sheep.
 - (b) A study of wool follicle activity by means of skin grafting.
- (iv) *Department of Textile Industries*
 The constitution of insect and plant waxes.

13. LIVERPOOL UNIVERSITY

- (i) *Department of Biochemistry*
 The metabolism of Vitamin A acid in animal tissues.
- (ii) *Department of Tropical Medicine*
 Research on the host responses of turkeys and chickens to protozoa.
- (iii) *Department of Veterinary Pathology*
 Research on the pathogenesis of fowl typhoid.
- (iv) *Department of Veterinary Preventive Medicine*
 - (a) Research on respiratory diseases in poultry.
 - (b) Serological studies of lungworm infection in farm animals.
 - (c) The housing and maintenance of the Reaseheath P line.
- (v) *Department of Zoology*
 Research on taste in birds.

14. LONDON UNIVERSITY

BIRKBECK COLLEGE

Department of Physics

The molecular structure of viruses.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

(i) *Department of Botany and Plant Technology*

(a) The metabolism of oat seedlings.

(b) The effect of sucrose on extension growth of cereal coleoptiles.

(ii) *Department of Chemistry*

The fixation of molecular nitrogen by micro-organisms.

(iii) *Departments of Zoology and Applied Entomology*

(a) Research on fumigation of seed-borne fungi with particular reference to loose smut of wheat.

(b) Research on insect ecology. (A five-year block grant).

KING'S COLLEGE

(i) *Department of Botany*

Nucleic acid metabolism in relation to endogenous rhythms and photoperiodism.

(ii) *Department of Zoology*

(a) Studies of *Fasciola hepatica* and other trematodes.

(b) Research on tick and other arthropod-borne diseases.

LISTER INSTITUTE OF PREVENTIVE MEDICINE

The enzymic synthesis and degradation of glycogen in rabbit muscle.

QUEEN ELIZABETH COLLEGE

Research on phytate and other magnesium-binding substances as a possible cause of hypomagnesaemia in ruminants.

QUEEN MARY COLLEGE

Department of Botany

(a) Research on photosynthesis.

(b) The effect of carbon dioxide on reactions of isolated chloroplasts.

ROYAL VETERINARY COLLEGE

(a) The relation between climatic environment and productivity in poultry.

(b) Studies on broiler production under closely controlled experimental conditions.

UNIVERSITY COLLEGE

(i) *Department of Biochemistry*

Research on adaptive enzyme synthesis in whole cells and subcellular fractions of *Pseudomonas* species.

(ii) *Department of Botany*

Research on the physiological role and metabolism of certain secondary nitrogenous substances in higher plants and micro-organisms.

UNIVERSITY COLLEGE HOSPITAL MEDICAL SCHOOL

Research on biliary secretions in the rabbit.

WYE COLLEGE

(a) The effect of water and nitrogen on the growth of apple trees.

(b) Research on pig breeding.

(c) Poultry research.

15. NATIONAL VEGETABLE RESEARCH STATION

The effect of sub-lethal doses of herbicides on vegetable crops.

16. NOTTINGHAM UNIVERSITY

School of Agriculture

- (a) The growth and development of the potato plant in relation to crop production techniques.
- (b) The development of buds of the potato tuber.
- (c) Methods of controlling the responses of plants to environmental conditions.
- (d) The effects on growth of divergence of actual from potential transpiration rates.
- (e) Research on oestrogen metabolism in sheep and cattle.
- (f) Studies in poultry nutrition.

17. OXFORD UNIVERSITY

(i) *Department of Agriculture*

- (a) Isotopic studies of root uptake from the soil and culture solutions.
- (b) The pattern of uptake of growth regulators by higher plants.
- (c) The physiological actions of growth regulators.
- (d) Research on the Take-All disease of cereals and grasses.

(ii) *Department of Entomology*

A taxonomic and biological study of parasites of the jumping plant lice (Fam. Psyllidae).

(iii) *Department of Pharmacology*

Plasma enzymes in the ruminant.

18. A.R.C. RADIOBIOLOGICAL LABORATORY

An investigation of the use of oxygen 15 in plant physiological studies.

19. READING UNIVERSITY

(i) *Department of Agriculture*

- (a) The effect of irrigation on the production of milk from grassland.
- (b) Poultry husbandry investigations.

(ii) *Department of Agricultural Botany*

- (a) The physiological and ecological aspects of crop growth.
- (b) Proposed investigation of physiological adaptations in ecotypes of *Trifolium repens* and *Festuca ovina*.
- (c) Water relations of vegetation on chalk grassland.

(iii) *Department of Botany*

The spatial arrangement of foliage area in vegetation.

(iv) *Department of Horticulture*

- (a) The effects of external conditions on the developmental physiology of the carnation.
- (b) The effects on plant growth and development of wave-length of light.

20. ROTHAMSTED EXPERIMENTAL STATION

Maintenance of the electronic computer in the Statistical Department.

21. ROWETT RESEARCH INSTITUTE

- (a) The absorption and elimination of natural and radio-active isotopes of calcium, strontium and barium in sheep.
- (b) Tests on protein in feeding stuffs.

22. SHEFFIELD UNIVERSITY

- (i) *Department of Bacteriology*
Research on toxoplasma infection in relation to bovine abortion.
- (ii) *Department of Microbiology*
 - (a) The growth of micro-organisms.
 - (b) The metabolism of the rumen organism *Selenomonas ruminantium*.
- (iii) *Department of Zoology*
Research on comparative endocrinology.

23. SWANSEA, UNIVERSITY COLLEGE

Department of Botany
Research on *Verticillium* wilt of Lucerne.

24. OTHER ORGANISATIONS

- (i) *Animal Health Trust, Farm Livestock Research Centre*
 - (a) Magnesium metabolism in animals.
 - (b) Research into Salmonellosis in calves.
- (ii) *Electrical Research Association*
 - (a) Crop conservation and storage.
 - (b) Farm machinery and equipment.
 - (c) Electricity in livestock husbandry.
 - (d) Electricity in horticulture.
 - (e) Specialised applications of electricity.
- (iii) *Ministry of Agriculture, Fisheries and Food*
Research on a continuous field drain-laying machine.
- (iv) *Research Contract with the Printing, Packaging and Allied Trades Research Association*
Investigation of horticultural packages.
- (v) *The Lord Rothschild, G.M., Sc.D., F.R.S.*
The physiology and ultra structure of spermatozoa. (A five-year block grant).

APPENDIX VI

SPECIAL EQUIPMENT GRANTS

During the year under review, the Council increased the scope of its assistance to universities by providing non-recurrent grants for the purchase of the following special items of research equipment:—

1. UNIVERSITY COLLEGE OF NORTH WALES, BANGOR
Department of Agricultural Chemistry
Infra-red spectrophotometer.
2. EDINBURGH UNIVERSITY
Department of Animal Genetics
Photomicrographic camera.
3. LONDON UNIVERSITY, KING'S COLLEGE
Department of Zoology
High speed refrigerated centrifuge.
4. LONDON UNIVERSITY, QUEEN ELIZABETH COLLEGE
Department of Nutrition
Flame photometer.

APPENDIX VII

SCIENTIFIC STAFF ATTACHED TO UNIVERSITIES OR RESEARCH INSTITUTES

PLANT BIOCHEMISTRY

School of Biochemistry, Cambridge

R. Hill, M.A., SC.D., F.R.S.

Long Ashton Research Station

D. J. D. Nicholas, D.SC., PH.D., A.K.C., F.R.I.C.

REPRODUCTION

Molteno Institute of Biology and Parasitology, Cambridge

Mrs. C. L. Mann, M.D., PH.D.

VITAMIN ASSAYS

Dunn Nutritional Laboratory, Cambridge

V. H. Booth, B.A., PH.D.

MEAT RESEARCH

School of Agriculture, University of Cambridge

R. W. Pomeroy, M.A., PH.D.

GRASS CONSERVATION

Department of Chemistry, University of Edinburgh

H. T. Macpherson, B.SC., PH.D.

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